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

**e-Meeting,** **August 16th – 27th, 2021**

**Agenda Item: 8.2.4**

**Source: Moderator (InterDigital, Inc.)**

**Title: Discussion Summary #2 for Beam Management for new SCSs**

**Document for: Discussion and Decision**

# **Introduction**

In this contribution, we summarize all issues discussed on beam management and timings associated with beam-based operation for new SCSs to support NR from 52.6 GHz to 71 GHz in RAN#106-e.

# **Timings Associated with Beam-based Operation**

## Support of additional values of beamSwitchTiming, beamReportTiming and timeDurationForQCL

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Proposal 1: There is no need to introduce any additional candidate value of “timeDurationForQCL”, “beamSwitchTiming” and “beamReportTiming” for 480kHz and 960kHz SCS.*** |
| [vivo, 2] | 1. For timeDurationForQCL, beamSwitchTiming and beamReportTiming, no additional candidate value is needed for 480 and 960 kHz.
 |
| [InterDigital, 4] | ***Observation 1:*** *Motivation to have decreased timing and timeline parameters associated with beam management is doubted as UE needs to decode DCI with similar DCI payload size while absolute amount of decreased PDCCH reception time is relatively smaller than lower SCSs due to smaller symbol duration.****Observation 2:*** *UE in 52.6-71 GHz may require a more complex UE implementation to handle higher phase noise, higher subcarrier spacing and increased number of antenna elements/panels.****Observation 3:*** *Motivation to have increased timing and timeline parameters associated with beam management is also doubted considering decreased PDCCH reception time due to smaller symbol/slot duration.****Proposal 1:*** *Maintain the agreed candidate values for timeDurationForQCL, beamSwitchTiming and beamReportTiming unless motivations are justified.* ***Observation 4:*** *While proposed new UE capability signaling design may reduce few RRC signaling overhead but it reduces signaling flexibility and may induce intensive discussion for the new design issues.* ***Proposal 2:*** *Maintain the existing UE capability signaling of timeDurationForQCL, beamSwitchTiming and beamReportTiming for 480/960 kHz SCSs.*  |
| [Sony, 5] | 1. **: While keeping the same time duration, extend the UE capabilities of *timeDurationForQCL*, *beamSwitchTiming* and *beamReportTiming* from SCS-60kHz and SCS-120kHz to SCS 480kHz and SCS 960kHz respectively.**
 |
| [Samsung, 7] | **Proposal 1: The value obtained by multiplying a factor of 4 or 8 to the value of 120 kHz SCSs is enough for *timeDurationForQCL, beamSwitchingTiming and beamReportTiming* for new SCSs****Proposal 2: Support UE indicates one value in OFDM symbols per each SCSs for beam-related UE capability** |
| [Ericsson, 10] | **Proposal 6 For 480/960 kHz SCS, RAN1 should discuss supporting additional candidate values for timeDurationForQCL, beamSwitchTiming, and beamReportTiming. For example, 28/56 symbols (2/4 slots) can be a starting point for discussion. For beamSwitchTiming, 448/896 symbols (32/64 slots) can be a starting point for discussion.** |
| [FUTUREWEI, 11] | **Proposal 3: The timing related parameter capability indicated by a UE for a SCS on which it cannot perform adjacent symbol beam switch is only guaranteed whenever to meet that capability it is not required to perform an adjacent symbol beam switch.**  |
| [OPPO, 14] | **Proposal 1: additional candidate values(s) for 480kHz and 960kHz are NOT needed.** |
| [MediaTek, 17] | **Proposal 1: Defer the discussion of additional values of timeDurationForQCL, beamSwitchTiming and beamReportTiming for 480 kHz and 960kHz till the BD/CCE limits are specified for 480kHz and 960kHz.** |
| [Intel, 18] | **Proposal 1:** Support additional candidate values of 28 OFDM symbols and 56 OFDM symbols for SCS 480 kHz and SCS 960 kHz, respectively, for each of the parameters: *timeDurationQCL*, *beamReportTiming* and *beamSwitchTiming*. |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 1.1 | Support additional values of beamSwitchTiming, beamReportTiming and timeDurationForQCL | Additional values* No additional values
	+ Huawei/HiSi, vivo, IDCC, Samsung, OPPO, MediaTek
* [vivo]: For timeDurationForQCL, beamSwitchTiming and beamReportTiming, no additional candidate value is needed for 480 and 960 kHz.
* [MediaTek]: Defer the discussion of additional values of timeDurationForQCL, beamSwitchTiming and beamReportTiming for 480 kHz and 960kHz till the BD/CCE limits are specified for 480kHz and 960kHz.
* Support additional candidate values
	+ Ericsson (e.g., scaled by 2x), Intel (28 symbols for 480 kHz and 56 symbols for 960 kHz)
* [Ericsson]: For 480/960 kHz SCS, RAN1 should discuss supporting additional candidate values for timeDurationForQCL, beamSwitchTiming, and beamReportTiming. For example, 28/56 symbols (2/4 slots) can be a starting point for discussion. For beamSwitchTiming, 448/896 symbols (32/64 slots) can be a starting point for discussion.
* [Intel]: Support additional candidate values of 28 OFDM symbols and 56 OFDM symbols for SCS 480 kHz and SCS 960 kHz, respectively, for each of the parameters: timeDurationQCL, beamReportTiming and beamSwitchTiming.
 |
| 1.2 | UE capability signaling method of beamSwitchTiming, beamReportTiming and timeDurationForQCL | UE capability signaling method for new SCSs* Reuse Rel-15/16 reporting mechanism (i.e., UE indicates one value in in OFDM symbols per SCS)
	+ IDCC, Sony, Samsung

[IDCC]: While proposed new UE capability signaling design may reduce few RRC signaling overhead but it reduces signaling flexibility and may induce intensive discussion for the new design issues.[Samsung]: Support UE indicates one value in OFDM symbols per each SCSs for beam-related UE capability |

### 1st round discussion

#### Observation 1

For timeDurationForQCL, beamSwitchTiming and beamReportTiming, it is observed that majority of companies indicated that no additional candidate values need to be additionally supported, while Ericsson and Intel indicated their preference to introduce additional candidate values.

#### Proposal 1

For timeDurationForQCL, beamSwitchTiming and beamReportTiming,

* No additional candidate values are supported for 120 kHz, 480 kHz and 960 kHz
* UE reports one value of the candidate values in OFDM symbols per each SCS

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## maxNumberRxTxBeamSwitchDL

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Observation 1: For 480kHz/960kHz, supporting the same values for maxNumberRxTxBeamSwitchDL as in 120kHz is challenging for UE implementation as well as system resource utilization. The benefits of keeping the legacy beam switching values need to be justified.******Proposal 2: Consider smaller values for maxNumberRxTxBeamSwitchDL in 480kHz and 960kHz, e.g., 2, 4, 7.*** |
| [vivo, 2] | Proposal 4: the definition of maxNumberRxTxBeamSwitchDL should be discussed in case of different numerology configuration for DL and UL. |
| [Spreadtrum, 3] | ***Proposal 1: Regarding “maxNumberRxTxBeamSwitchDL”, the number of Tx and Rx beam changes UE can perform should be scale down to {2, 4, 7} within a slot.*** |
| [InterDigital, 4] | ***Proposal 4:*** *maxNumberRxTxBeamSwitchDL should be supported for 480kHz/960kHz SCSs.****Proposal 5:*** *As a slot duration decreases in 480kHz/960kHz SCSs, it is preferred to reduce candidate values of maxNumberRxTxBeamSwitchDL.****Proposal 6:*** *Support the candidate values of 240 kHz by scaling down by 2 and 4 for 480kHz/960kHz SCSs, respectively. Additional values can be further discussed, if needed.* |
| [Sony, 5] | 1. **: Support new parameter value(s) of UE capability on *maxNumberRxTxBeamSwitchDL* for SCS 480kHz and SCS 960kHz respectively and these new values e.g. ‘n1’ and ‘n2’ can be FFS.**
 |
| [Samsung, 7] | **Proposal 3: Support following candidate values for *maxnumberRxTxBeamSwitchDL**** **For 480 kHz {2, 4}**
* **For 960 kHz {2}**
 |
| [CATT, 8] | **Observation 2: When SCS is 480KHz or 960KHz, the duration of each OFDM symbol would be shorter. UE may not support performing beam switching as much as 14 times within a slot.****Proposal 3: For SCS 480/960 kHz, the minimum and maximum available value of *maxNumberRxTxBeamSwitchDL* should be reduced.** |
| [ZTE/Sanechips, 9] | **Proposal 1: For NR operation in 52.6 ~ 71 GHz, the following values of *maxNumberRxTxBeamSwitchDL* for SCS 120/480/960 kHz are preferred.**

|  |  |
| --- | --- |
| **Subcarrier spacing** | **Proposed value of *maxNumberRxTxBeamSwitchDL*** |
| **120 kHz** | **4, 7, 14** |
| **480 kHz** | **[1], 2, 4, 7** |
| **960 kHz** | **[1], 2, 4, 7** |

 |
| [Ericsson, 10] | **Proposal 8 For 480 and 960 kHz SCS, support a value range of {4,7,14} for the UE capability parameter maxNumberRxTxBeamSwitchDL.** |
| [FUTUREWEI, 11] | **Proposal 4: For maxNumberRxTxBeamSwitchDL we propose the set {1, 2, 4, 7, [14]}.**  |
| [Nokia/NSB, 12] | ***Proposal 1:*** *Values for maxNumberRxTxBeamSwitchDL should be* ≥2 *for both 480 and 960 kHz SCS.* |
| [MediaTek, 17] | **Proposal 2: For maxNumberRxTxBeamSwitchDL, the candidate values of {4, 7, 14} supported in FR2-1 are reused for 120kHz in FR2-2.****Proposal 3: For maxNumberRxTxBeamSwitchDL, the UE should support at least {**$\leq 3$**} for 480kHz and at least {1} for 960kHz in FR2-2. Additional values should be discussed after the RAN4 decision on the beam switching time in 480kHz and 960kHz.** |
| [Intel, 18] | **Proposal 2:** For *maxNumberRxTxBeamSwitchDL*: Candidate value set is {2, 4, 7, 14} switches. |
| [Apple, 19] | * New value range for *maxNumberRxTxBeamSwitchDL* may need to be considered for 480/960kHz SCS depending on the RAN 4 conclusion on “Minimum duration between beam switches”.
 |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | maxNumberRxTxBeamSwitchDL | **Support smaller candidate values of maxNumberRxTxBeamSwitchDL for new SCSs (Note: the candidate values of 120kHz = (4, 7, 14))*** Huawei/HiSi, Spreadtrum, IDCC, Sony, Samsung, CATT, ZTE/Sanechips, FUTUREWEI, Nokia/NSB, MediaTek, Intel
* [Huawei/HiSi]: For 480kHz/960kHz, supporting the same values for maxNumberRxTxBeamSwitchDL as in 120kHz is challenging for UE implementation as well as system resource utilization. The benefits of keeping the legacy beam switching values need to be justified.
* [CATT]: For SCS 480/960 kHz, the minimum and maximum available value of maxNumberRxTxBeamSwitchDL should be reduced.

**Proposed candidate values for 480 kHz** * (1, 2): Sony
* (1, 2, 4, 7): Futurewei (with [14])
* (≥2): Nokia/NSB
* (2, 4): Samsung
* (2, 4, 7): Huawei/HiSi, Spreadtrum, IDCC, ZTE/Sanechips (with [1])
* (2, 4, 7, 14): Intel
* (≤3): MediaTek
* (4, 7, 14): Ericsson

**Proposed candidate values for 960 kHz*** (≥1): MediaTek
* (1, 2): Sony,
* (1, 2, 3): IDCC
* (1, 2, 4, 7): Futurewei (with [14])
* (2): Samsung (960 kHz)
* (≥2): Nokia/NSB
* (2, 4, 7, 14): Intel
* (4, 7, 14): Ericsson
 |

### 1st round discussion

#### Observation 2

For maxNumberRxTxBeamSwitchDL, it is observed that majority of companies indicated that smaller candidate values than the candidate values of 120 kHz should be supported for 480 kHz and 960 kHz, while Ericsson indicated their preference to reuse the existing candidate values of 4, 7 and 14 symbols for new SCSs. In addition, majority of companies indicated their preference to support 2 and 4 symbols for 480 kHz and 2 for 960 kHz.

#### Proposal 2

* For maxNumberRxTxBeamSwitchDL,
	+ Support at least 2 and 4 symbols as candidate values for 480 kHz
	+ Support at least 2 symbols as a candidate value for 960 kHz
	+ FFS: Support for additional candidate value(s)

|  |  |
| --- | --- |
| **Company** | **Input** |
| Moderator | 1st round discussion is closed. Please check the agreement in 2.2.3.3 and continue the discussion in 2.2.4. |

#### Conclusions from GTW session

Agreement:

For maxNumberRxTxBeamSwitchDL,

* Support at least 2 and 4 as candidate values for 480 kHz
	+ FFS: 7
* Support at least 2 as a candidate value for 960 kHz
	+ FFS: Support for additional candidate value(s) including 4

### 2nd round discussion

Please share your views on whether to support additional value (e.g., 7 for 480 kHz and 4 for 960 kHz).

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |

## Additional beam switching time delay d

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Proposal 3: For the additional beam switching time delay d, when triggering PDCCH with 120kHz (480kHz) has a smaller subcarrier spacing than AP-CSI-RS or PDSCH, the supported value is obtained by multiplying a factor of two (eight) to the corresponding value for 60 kHz SCS.*** |
| [InterDigital, 4] | ***Observation 5:*** *As well as other beam related parameters, processing time reduction may be difficult considering the similar DCI payload size and the more complex UE implementation.****Proposal 3:*** *As shown in Table 2, support values scaled by 2x and 8x of Additional beam switching time delay d for 120kHz/480 kHz SCSs, respectively.*  |
| [CATT, 8] | The value in specification (TS 38.214) may change as below: Table 1: Additional beam switching timing delay *d*

|  |  |
| --- | --- |
| ***µPDCCH*** | ***d* [PDCCH symbols]** |
| 0 | 8 |
| 1 | 8 |
| 2 | 14 |
| 3 | 26 |
| 5 | 48 |
| 6 | 90 |

 |
| [ZTE/Sanechips, 9] | **Proposal 2: The following values can be considered for additional beam switching time delay *d* for triggering AP-CSI-RS when triggering PDCCH with 120/480kHz has a smaller SCS than AP-CSI-RS.**

|  |  |
| --- | --- |
| ***µPDCCH*** | ***d* [PDCCH symbols]** |
| 3 | 28 |
| 5 | 56 |

 |
| [Ericsson, 10] | **Proposal 7 An upper bound on the value of the additional beam switching delay for cross-carrier triggering of aperiodic CSI-RS on carriers with different numerologies is d = 14 and 56 for µPDCCH = 3 and 5, respectively. Further discuss if these values can be tightened, e.g., by a factor of 2.** |
| [Intel, 18] | **Proposal 3:** For additional beam switching delay $d$, support [14] PDCCH symbols when $μ\_{PDCCH}=3$ (SCS 120 kHz), support [56] PDCCH symbols when $μ\_{PDCCH}=5$ (SCS 480 kHz). |
| [Apple, 19] | **Proposal 1: For additional beam switching time delay ‘d’, reuse the absolute time defined for 60kHz i.e., 28 symbols for 120kHz and 112 symbols for 480kHZ.** |
| [NTT DOCOMO, 20] | * **New parameter values need to be defined for beam switching time delay *d* for triggering AP-CSI-RS by a PDCCH with a smaller subcarrier spacing than that for AP-CSI-RS.**
 |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | Value of additional beam switching time delay d for 120 kHz | 14 symbols* Ericsson, Intel
* [Ericsson]: An upper bound on the value of the additional beam switching delay for cross-carrier triggering of aperiodic CSI-RS on carriers with different numerologies is d = 14 and 56 for µPDCCH = 3 and 5, respectively. Further discuss if these values can be tightened, e.g., by a factor of 2.

26 symbols* CATT

28 symbols (Value of 60 kHz scaled by 2x)* Huawei/HiSi, IDCC, ZTE/Sanechips, Apple
* [IDCC] As shown in Table 2, support values scaled by 2x and 8x of Additional beam switching time delay d for 120kHz/480 kHz SCSs, respectively.
 |
| 3.2 | Value of additional beam switching time delay d for 480 kHz | 48 symbols * CATT

56 symbols* ZTE/Sanechips, Ericsson, Intel
* [Intel] For additional beam switching delay d, support [14] PDCCH symbols when μ\_PDCCH=3 (SCS 120 kHz), support [56] PDCCH symbols when μ\_PDCCH=5 (SCS 480 kHz).

112 symbols (Value of 60 kHz SCS scaled by 8x)* Huawei/HiSi, IDCC, Apple
* [Huawei/HiSi] For the additional beam switching time delay d, when triggering PDCCH with 120kHz (480kHz) has a smaller subcarrier spacing than AP-CSI-RS or PDSCH, the supported value is obtained by multiplying a factor of two (eight) to the corresponding value for 60 kHz SCS.
 |

### 1st round discussion

#### Observation 3

For additional beam switching time delay d, majority of companies supported 28 symbols for 120 kHz, however, no clear majority was observed for 480 kHz.

#### Proposal 3

* For additional beam switching time delay d, support 28 symbols for 120 kHz
	+ FFS: value of 480 kHz

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Beam switching gap and scheduling restrictions for higher SCSs

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Observation 2: This WI can discuss if the beam switching behavior between adjacent symbols is ambiguous in some cases and if it is necessary to clarify the definition of maxNumberRxTxBeamSwitchDL for those cases.*** ***Observation 3: For 960kHz and 480 kHz SCS, current scheduling restrictions cannot protect the reception or transmission of a signal with a higher priority when an adjacent symbol carries a signal with a lower priority and using a different beam.******Proposal 4: For 960 kHz and 480 kHz SCS, apply further scheduling restrictions on the adjacent symbols to the signal with a higher priority when the adjacent symbol carries a signal with a lower priority and using a different beam.*** |
| [Spreadtrum, 3] | ***Observation 1: For the presence of gap symbol(s), some impact may exist for scheduling.*** |
| [Lenovo/MotM, 6] | ***Observation 1: For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, for the agreed higher subcarrier spacings (numerologies) such as 960kHz, beam switching issue would appear between the contiguous transmissions (such as SSB beams) since the CP length would not be enough for beam switching, and an extra gap might be needed to prevent performance degradation******Proposal 1: For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for SSB, then to allow the beam switching between contiguous SSBs, a gap (for example a symbol gap or post prefix) should be supported between contiguous SSB at least for 960kHz SCS*** |
| [Samsung, 7] | **Proposal 4: Reserve one symbol for beam switching gap when using 480 kHz and 960 kHz SCSs.** |
| [CATT, 8] | **Observation 4: In order to guarantee the reception performance of PDSCH, the additional beam switching gap need to be reserved before the PDSCH.****Proposal 5: When the additional beam switching gap is introduced, QCL assumption needs to be investigated.** |
| [ZTE/Sanechips, 9] | **Observation 1: Rel-15/16 NR specifications have enough flexibility to support beam switching for non-SSB channels/signals with new SCSs 480 kHz and 960 kHz, even if the lengths of CP are not enough for beam switching.** |
| [Ericsson, 10] | **Proposal 9 To allow efficient configuration of reference signal resource sets for beam management for 480/960 kHz SCS, RAN1 should further discuss the introduction of some form of UE capability signalling that can provide the network with knowledge related to the UE beam switch time (on the order of 10s of ns, rather than 10s of symbols).** |
| [FUTUREWEI, 11] | **Proposal 1: For both 480 kHz and 960 kHz SCS, UE is not expected to be able receive downlink data or control channel or reference signals with different QCL-TypeD properties on adjacent symbols within a slot if that violates its signaled beam switch capability or if this capability is not signaled.****Proposal 2: Precedence relations must be defined to allow a UE incapable of adjacent symbol beam switch, to determine which symbol(s), if any, to switch on for all instances entailing adjacent symbol beam switch.**  |
| [Nokia/NSB, 12] | ***Proposal 2:*** *No explicit beam switching gap is introduced between DL signals and channels.* |
| [NEC, 13] | ***Proposal 2:*** ***A gap for beam switching or directional LBT should be introduced for multiple-PDSCH scheduling.******Proposal 3: UE should apply the QCL assumption(s) of the smallest CORESET ID that LBT succeed in the latest slot for each PDSCH when some or all of the scheduled PDSCHs of the multiple PDSCH have scheduling offset less than timeDurationForQCL for shared spectrum.*** |
| [Qualcomm, 15] | **Proposal 1: Introduce a minimum interval between start of two consecutive beam switches.*** **The value can be X symbols per SCS and can be UE capability.**

**Proposal 2: Introduce explicit beam switch gaps at least in the following scenarios for 480 and 960 KHz SCSs.*** **Between different SSBs.**
* **Between CSI-RS resources in a resource set with higher layer parameter *Repetition* configured as ON.**
 |
| [Intel, 18] | **Observation 1:** For larger SCS, the configuration of time gaps between PDSCH and CSI-RS does not require new specification work as the gaps could be configured relying on existing NR mechanisms. |
| [NTT DOCOMO, 20] | * **For beam switching between SRS/PUCCH/PUSCH, whether/how to define the beam switching gap depends on RAN4 conclusion on “transient period” and “UE beam switching time (beam direction switch only)”.**
* **Value(s) for the SRS antenna switching gap should be defined for 480 and 960kHz SCS.**
 |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 4.1 | Introduction of beam switching gap or scheduling restriction | **Beam switching gap:** Lenovo/MotM, Samsung, CATT, NEC, NTT Docomo (SRS)* [Lenovo/MotM]: beam switching issue would appear between the contiguous transmissions (such as SSB beams) since the CP length would not be enough for beam switching, and an extra gap might be needed to prevent performance degradation.
* [Qualcomm]: Introduce explicit beam switch gaps at least in the following scenarios for 480 and 960 KHz SCSs.
	+ Between different SSBs.
	+ Between CSI-RS resources in a resource set with higher layer parameter Repetition configured as ON.

**Scheduling restriction:** Huawei/HiSi, Spreadtrum, FUTUREWEI* [FUTUREWEI]: For both 480 kHz and 960 kHz SCS, UE is not expected to be able receive downlink data or control channel or reference signals with different QCL-TypeD properties onadjacent symbols within a slot if that violates its signaled beam switch capability or if this capability is not signaled.

**No:** ZTE/Sanechips, Nokia/NSB, Intel, * [ZTE/Sanechips] Rel-15/16 NR specifications have enough flexibility to support beam switchingfor non-SSB channels/signals even if the lengths of CP are not enough for beam switching
 |
| 4.2 | Introduction of UE capability reporting on UE beam switching time | **Yes:** Ericsson, Qualcomm* [Ericsson] To allow efficient configuration of reference signal resource sets for beam management for 480/960 kHz SCS, RAN1 should further discuss the introduction of some form of UE capability signalling that can provide the network with knowledge related to the UE beam switch time (on the order of 10s of ns, rather than 10s of symbols).
 |

### 1st round discussion

#### Observation 4

For introduction of beam switching time gap, 10 companies indicated their views to support beam switching gap or scheduling restriction as CP length of new SCSs would not be enough. However, 5 companies indicated that beam switching issues can be handled by gNB implementation. In addition, 2 companies indicated their preference to introduce new UE capability signaling to report UE beam switch time.

Please share your views on whether/how to support beam switching time gap, scheduling restriction and UE capability signaling to report UE beam switch time.

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

#### Proposal 4

TBU

## Other parameters

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [vivo, 2] | 1. As a UE capability, UE can report buffer capability (e.g., number of symbols).

**Proposal 3: The value 48 for threshold of beam switching should be retuned accordingly.** |
| [Ericsson, 10] | **Observation 1 To support 480 and 960 kHz, RAN1 needs to discuss how to extend the signaling of the triggering offset for an aperiodic CSI-RS resource set (*aperiodicTriggeringOffset*) to cover a wider range than 0 .. 31 slots. Signaling of up to 192 slots is needed with a sufficient level of granularity.** |
| [LG Electronics, 16] | **Proposal #1: When one of the values {224x4, 336x4} for 480 kHz or one of the values {224x8, 336x8} for 960 kHz is provided for *beamSwitchTiming*, define 192 symbols for 480 kHz or 384 symbols for 960 kHz as the beam switching threshold which is used to determine different QCL assumptions for triggered aperiodic CSI-RS depending on the offset between PDCCH and CSI-RS.** |

### 1st round discussion

#### Observation 5

Two companies indicated their preference to define beam switching threshold for 480 kHz and 960 kHz. In addition, 1 company indicated their view to extend the triggering offset for an aperiodic CSI-RS resource set.

Please provide your views on the beam switching threshold and extension of the triggering offset for an aperiodic CSI-RS resource set.

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

#### Proposal 5

TBU

# **Multiple QCL Assumptions for Multiple PDSCHs/PUSCHs**

## Multiple QCL assumptions based on timeDurationForQCL

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Observation 4: In the slots with offset smaller than timeDurationForQCL, UE may receive and buffer signals in each slot using a different beam associated with the lowest CORESET ID of the latest monitored slot.******Proposal 5: When the offset of the scheduled PDSCHs using single DCI is smaller than timeDurationForQCL, support receiving each of those PDSCHs with a default TCI state that is associated with a monitored search space with the lowest CORESET ID in the latest slot to that PDSCH.*** |
| [vivo, 2] | Proposal 5: only support single QCL assumption for multiple PDSCHs scheduled by a single DCI |
| [Spreadtrum, 3] | ***Proposal 2: The scheduled PDSCHs with scheduling offset less than timeDurationForQCL are assumed to be quasi co-located with the lowest CORESET ID, and the scheduled PDSCHs with scheduling offset equal to or greater than timeDurationForQCL are assumed to be quasi co-located with the RS(s) in the TCI state.******Proposal 3: In case of when all of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL, the scheduled PDSCHs are assumed to be quasi co-located with the lowest CORESET ID.*** |
| [InterDigital, 4] | ***Proposal 7:*** *When all or some of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL, apply a beam of the firstly scheduled PDSCH for all of the scheduled PDSCHs.* |
| [Sony, 5] | Proposal 5 : For single DCI scheduled multiple PDSCH, UE applies the same default Rx beam from the 1st PDSCH to the last PDSCH.Proposal 6 : For the case when all scheduled PDSCH are within timeDurationForQCL, UE applies the same default Rx beam of the 1st PDSCH to all other PDSCH. |
| [Lenovo/MotM, 6] | ***Proposal 4: For NR operation between 52.6 GHz and 71 GHz with high subcarrier spacing values such as 480kHz and 960kHz, specify enhancements to support multiple default beams association for multiple PDSCHs scheduled by single DCI:**** ***PDCCH CORESET can be associated with multiple QCL assumptions (beams) that can be used to determine multiple default beams based on lowest CORESET ID***
* ***Duration/applicability for each of the default beams can also be associated to allow UE to determine when to switch from one default beam to another during the duration of multiple PDSCH transmission***
 |
| [Samsung, 7] | **Proposal 5: Use the first PDSCH occasion as a reference to determine the latest slot containing CORESET to monitor for the case when all of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL****Proposal 6: Use indicated QCL assumption when an enough gap for beam switching is provided, otherwise keep default QCL assumption.** |
| [CATT, 8] | **Observation 3:** **In some scenarios, PDSCH**(s) **QCL’d with the RS in the TCI state indicated by the DCI can achieve reception gain; while in other scenarios PDSCH**(s) **QCL’d with the PDSCH(s) which have scheduling offset less than timeDurationForQCL can achieve reception gain.****Proposal 4: When some of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL and some have scheduling offset equal to or greater than timeDurationForQCL, both options below should be supported for the scheduled PDSCHs have scheduling offset equal to or greater than timeDurationForQCL. FFS conditions to determine the QCL assumption.*** **The scheduled PDSCHs 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 in DCI.**
* **The scheduled PDSCHs quasi co-located with the RS(s) based on the activated TCI states in the first slot with the scheduled PDSCH.**
 |
| [ZTE/Sanechips, 9] | **Proposal 3: If all PDSCHs scheduled by a single DCI with scheduling offsets less than the threshold *timeDurationForQCL,* same default QCL assumption(s) can be adopted.*** + **All scheduled PDSCHs follows a same default QCL assumption as the first PDSCH**

**Proposal 4: If all PDSCHs scheduled by a single DCI with the scheduling offset equal to or greater than the threshold *timeDurationForQCL*, same QCL assumption(s) can be adopted.*** + **Case 1-1: *tci-PresentInDCI* is set as ‘enabled’ and the DCI format has TCI field present**
		- * **Single QCL assumption based on the indicated single TCI state is applied for all scheduled PDSCHs**
	+ **Case 1-2: *tci-PresentInDCI* is not configured or the DCI format has no TCI field present**
		- * **QCL assumption of the single DCI that schedules multi-PDSCHs is applied for all scheduled PDSCHs**

**Proposal 5: If some of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL while some have scheduling offset equal to or greater than *timeDurationForQCL**** + **All PDSCH(s) that has scheduling offset less than *timeDurationForQCL* follows a same default QCL assumption, as given in Proposal 3**
	+ **All PDSCH(s) that has scheduling offset equal to or greater than *timeDurationForQCL* follows a same QCL assumption, as given in Proposal 4**
 |
| [Ericsson, 10] | 1. For single-TRP operation, for multiple PDSCHs scheduled by a single DCI support the following:
	* + Case 1: PDSCH scheduling offset for all PDSCHs ≥ *timeDurationForQCL*
			- Case 1-1: *tci-PresentInDCI* enabled
				* The UE applies the same QCL assumption corresponding to the TCI state indicated by the single TCI field in DCI for all scheduled PDSCHs
			- Case 1-2: *tci-PresentInDCI* disabled
				* The UE applies the same default QCL assumption for all scheduled PDSCHs (*DefaultQCL1*)
		+ Case 2: PDSCH scheduling offset for any PDSCH < *timeDurationForQCL*
			- The UE applies the same default QCL assumption for all scheduled PDSCHs (*DefaultQCL2*)
2. For Case 1-2 in Proposal 1, the default QCL assumption *DefaultQCL1* is provided by the active TCI state associated to the CORESET corresponding to the detected scheduling DCI. Note: this is analogous to Rel-16 for single-PDSCH scheduling when the PDSCH scheduling offset is ≥ *timeDurationForQCL*.
3. For Case 2 in Proposal 1, default QCL assumption *DefaultQCL2* is the default QCL assumption corresponding to the first scheduled PDSCH, i.e., the one with the smallest scheduling offset. The default QCL assumption for the first PDSCH is the same as that specified in Rel-16 for single-PDSCH scheduling when the scheduling offset < *timeDurationForQCL*.
4. Support cross-carrier scheduling of multiple-PDSCHs with a single DCI. A single QCL assumption is applied for all scheduled PDSCHs in a parallel way to Proposal 1. For Case 1-1, the single QCL assumption is indicated by the TCI field in the scheduling DCI. The default QCL assumptions for Case 1-2 and Case 2 are defined in the same way as for cross-carrier scheduling in Rel-16.
 |
| [FUTUREWEI, 11] | ***Observation 1: Changes to Rel.15 default beam assumptions in single DCI multi-slot PDSCH scheduling can result in need for provisioning of larger number of gap symbols.***  |
| [Nokia/NSB, 12] | ***Observation 1:*** *If some of PDSCHs in multi-PDSCH scheduling are allocated with scheduling offset less than timeDurationForQCL the UE would have different QCL assumptions for the PDSCHs allocated with scheduling offset than timeDurationForQCL and for the PDSCH allocated with scheduling offset equal to and greater than timeDurationForQCL.****Proposal 3:*** *Support single QCL assumption for the multi-PDSCH transmission in case of some of the PDSCHs are having lower scheduling offset than timeDurationForQCL.* ***Observation 2:*** *gNB can by the configuration/scheduling guarantee that the UE may apply the same QCL-TypeD RS for the reception of the multi-PDSCH transmission even though some of the PDSCHs would have scheduling offset less than timeDurationForQCL.****Proposal 4:*** *NW ensures single QCL assumption across the slots for the multi-PDSCH transmission.* |
| [NEC, 13] | ***Proposal 1: The current Rel-16 behavior can be directly extended to multiple-PDSCH scheduling. And different QCL assumption can be supported for multiple-PDSCH transmission.*** |
| [OPPO, 14] | **Proposal 2: for multiple PDSCHs/PUSCHs scheduled by a single DCI for single TRP:** * **If the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold timeDurationForQCL, the UE shall follow the QCL assumption of the CORESET on the latest slot to determine the QCL assumption of the PDSCH.**
* **If the offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than the threshold timeDurationForQCL, the UE shall follow the TCI-state indication in the DCI to determine the QCL assumption of the PDSCH.**
 |
| [Qualcomm, 15] | **Proposal 3: Support dedicated configuration of default PDSCH beam for better optimization flexibility*.**** **gNB can dynamically update the default PDSCH beam via MAC-CE.**
 |
| [LG Electronics, 16] | **Proposal #2: Consider the following approaches when all or some of PDSCHs scheduled by a single DCI have scheduling offset less than *timeDurationForQCL*.*** + **Approach 1: The scheduled PDSCHs that have scheduling offset less than timeDurationForQCL apply the same QCL parameter(s) used for the lowest index CORESET in the latest slot from the first scheduled PDSCH.**
	+ **Approach 2: If at least one of scheduled PDSCHs has scheduling offset less than timeDurationForQCL, all of scheduled PDSCHs apply the same QCL parameter(s) used for the lowest index CORESET in the latest slot from the first scheduled PDSCH.**
	+ **FFS when some of PDSCHs are collided with semi-static UL symbols and then skipped**
 |
| [MediaTek, 17] | **Proposal 4: For the reception of multi-PDSCHs scheduled by a single DCI within the duration specified by timeDurationForQCL, current Rel-15/16 default beam assumption should be applied.** |
| [Intel, 18] | **Proposal 5:** When scheduling offset of PDSCH from multi-PDSCH transmission is greater than *timeDuraionForQCL* and *tci-PresentInDCI* is enabled, the UE should apply QCI assumption(s) indicated in the scheduling DCI. Otherwise, the UE should apply the default QCL assumption(s) which corresponds to one of the semi-statically configured PDSCH TCI states for the UE.* FFS: Which TCI state from the dedicated UE configuration is the default.
 |
| [Apple, 19] | **Proposal 2: Support a mechanism to allow a single QCL assumption at least for multi-PDSCH scheduled by a single DCI that have** **scheduling offset less than timeDurationForQCL.**  |
| [NTT DOCOMO, 20] | * **For multi-PDSCH scheduling, regardless of the offset between scheduling DCI and PDSCHs relative to timeDurationForQCL, TCI states for PDSCHs scheduled by a single DCI follows the TCI state applied for the first PDSCH.**
 |
| [Xiaomi, 21] | ***Proposal 1: For the scheduled PDSCHs have scheduling offset less than timeDurationForQCL, the QCL assumption is the same as the PDSCH in the first TTI, which is determined by R16 behavior. And for the scheduled PDSCHs have scheduling offset equal to or greater than timeDurationForQCL, the QCL assumption is the same as the PDCCH scheduling the PDSCHs when there is no TCI indication field in the scheduling DCI, or the QCL assumption is indicated by the TCI indication field, if it exists, in the scheduling DCI.*** |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 6.1 | Support of multiple beams based on timeDurationForQCL | **Yes (multiple beams):** Huawei/HiSi, Spreadtrum, Lenovo/MotM, FUTUREWEI, NEC, MediaTek* [Oppo]: for multiple PDSCHs/PUSCHs scheduled by a single DCI for single TRP:
	+ If the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold timeDurationForQCL, the UE shall follow the QCL assumption of the CORESET on the latest slot to determine the QCL assumption of the PDSCH.
	+ If the offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than the threshold timeDurationForQCL, the UE shall follow the TCI-state indication in the DCI to determine the QCL assumption of the PDSCH.
* [FW]: Necessity of any changes to default beam assumptions in single DCI multi-slot PDSCH scheduling should be clarified first.

**No (single beam):** vivo, IDCC, Sony, Samsung, ZTE/Sanechips, Ericsson, Nokia/NSB, LGE, Intel, Apple, NTT Docomo, Xiaomi* [Sony]: For single DCI scheduled multiple PDSCH, UE applies the same default Rx beam from the 1st PDSCH to the last PDSCH.
* [ZTE/Sanechips]: If all PDSCHs scheduled by a single DCI with scheduling offsets less than the threshold timeDurationForQCL, same default QCL assumption(s) can be adopted.
	+ All scheduled PDSCHs follows a same default QCL assumption as the first PDSCH
* [QC]: Support dedicated configuration of default PDSCH beam for better optimization flexibility.
	+ gNB can dynamically update the default PDSCH beam via MAC-CE.

**Both:** Samsung (if enough gap is provided), CATT (based on resource reservation)* [Samsung]: Use indicated QCL assumption when an enough gap for beam switching is provided, otherwise keep default QCL assumption.
* [CATT]: When some of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL and some have scheduling offset equal to or greater than timeDurationForQCL, both options below should be supported for the scheduled PDSCHs have scheduling offset equal to or greater than timeDurationForQCL. FFS conditions to determine the QCL assumption.
 |

### 1st round discussion

#### Observation 6

No clear majority was observed on whether to support multiple beams based on timeDurationForQCL. Some companies provided their understanding on the existing UE behavior on the support of multiple beams based on timeDurationForQCL. For example, some companies argued that support of default TCI state would be the existing UE behavior while some other companies argued that support of TCI determination based on the latest CORESET of each PDSCH would be the existing UE behavior. In Moderator’s understanding, as multi-PDSCH transmission by a single DCI is not specified, there should be no existing behavior. Given that, Moderator recommends not to argue the existing UE behavior for multi-PDSCH and continue discussion based on the previous proposal in RAN1#104bis-e.

#### Proposal 6

* For multi-PDSCHs scheduled by a single DCI with a single TCI state,
	+ Case 1: PDSCH scheduling offset for all PDSCHs ≥ *timeDurationForQCL*
		- Case 1-1: *tci-PresentInDCI* enabled
			* Single QCL assumption based on the indicated single TCI state is applied for all scheduled PDSCHs
		- Case 1-2: *tci-PresentInDCI* disabled
			* QCL assumption of the single DCI scheduled multi-PDSCHs is applied for all scheduled PDSCHs
	+ Case 2: PDSCH scheduling offset for any scheduled PDSCH < *timeDurationForQCL*
		- Down select one of the following alternatives
			* Alt 1: Single QCL assumption is applied for all scheduled PDSCHs
				+ FFS: Details of single QCL assumption, if supported
			* Alt 2: multiple QCL assumptions are applied
				+ ~~Any PDSCH(s) with scheduling offset <~~ *~~timeDurationForQCL~~* ~~follows QCL assumption of the lowest CORESET ID in the latest monitored slot~~
				+ FFS: Details of multiple QCL assumptions, if supported

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Multiple TCI states/SRIs for multiple PDSCHs/PUSCHs with multi-TRPs

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Proposal 6: The design of multi-TRP multi-PDSCH scheduling can be considered as a lower priority discussion in this WI.*** |
| [vivo, 2] | Proposal 6: For eMBB in M-TRP, support two S-DCI based M-PDSCH/PUSCH scheduling associated with two different CORESET pool index respectively. For URLLC in M-TRP, S-DCI based single PDSCH/PUSCH repetition can be extended to multi-PDSCHs/PUSCHs. |
| [Spreadtrum, 3] | ***Proposal 4: The number of TCI states/SRIs in a single DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP should be equal to the number of TRPs.*** |
| [InterDigital, 4] | ***Observation 6***: *Performance gain from multi-TRP based multi-beam transmission should be carefully evaluated.* ***Proposal 8:*** *Support single beam indication (i.e., single TCI state/SRI indication) for multi-PDSCH/PUSCH scheduling.* |
| [Sony, 5] | **Proposal 4: For single-DCI scheduled multi-PDSCH/PUSCH for multi-TRP, support up to 2 TCI states/SRIs and each TCI state/SRI is from/to each TRP.** |
| [Lenovo/MotM, 6] | ***Proposal 2: For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, when multiple PDSCHs are scheduled via single DCI to be received from two TRPs (not all PDSCHs received from one TRP), then indication of at least two TCI states should be supported******Proposal 3: For NR operation between 52.6 GHz and 71 GHz when multiple PDSCHs are scheduled via single DCI to be received from two TRPs (not all PDSCHs received from one TRP), then the duration for which each TCI state is valid should also be indicated*** |
| [Samsung, 7] | **Proposal 7: Support 2 TCI state/SRI indication for multi- PDSCH/PUSCH scheduled by a single DCI for multi-TRP.****Proposal 8: Support TCI state/SRI indication rule for multi- PDSCH/PUSCH scheduled by a single DCI for multi-TRP, which has the same approach as the QCL assumptions of single-DCI based multi-TRP operation with inter-slot PDSCH repetition.** |
| [CATT, 8] | **Proposal 6: If single DCI schedule multi-PUSCH/PDSCH is supported,** **multiple beam indications of PDSCH with different TCI states need to be investigated.****Proposal 7: If separate TCI state for each scheduled PDSCH introduced for multi-PDSCH scheduling with a single DCI, the solution for overhead reduction need to be investigated.** |
| [ZTE/Sanechips, 9] | **Proposal 6: For multiple PDSCHs/PUSCHs scheduled by a single DCI, for multi-TRP, support only a single TCI/SRI field in the DCI.*** + **For M-DCI scheme, a single TCI state is indicated by the field for one TRP**
	+ **For S-DCI scheme, one or two TCI states in a codepoint are indicated by the field for TRPs**
 |
| [Ericsson, 10] | 1. Support multi-PDSCH scheduling for multi-TRP operation for both single-DCI and multi-DCI modes. A single QCL assumption per-TRP is applied for all scheduled PDSCHs in a parallel way to Proposal 1. For Case 1-1, the single QCL assumption is indicated by the single TCI field in the scheduling DCI. The default QCL assumptions for Case 1-2 and Case 2 are defined in the same way as for multi-TRP operation in Rel-16.
 |
| [Nokia/NSB, 12] | ***Proposal 5:*** *In multi-TRP case, single QCL assumption is applied for the multiple scheduled PDSCHs per TRP.*   |
| [OPPO, 14] | **Proposal 3: support indication of multiple TCI states/SRIs in a DCI for multiple PDSCHs/PUSCHs scheduled by a single DCI for multi-TRP.**  |
| [LG Electronics, 16] | **Proposal #3: For multi-TRP case, support to indicate two TCI states in a multi-PDSCH scheduling DCI and further study how to apply SDM/FDM/TDM schemes defined in Rel-16.*** + **FFS for multi-PUSCH scheduling DCI**
 |
| [MediaTek, 17] | **Proposal 5: For multi-TRP, support only single TCI field in the DCI scheduling multi-PDSCHs.** |
| [Intel, 18] | **Proposal 4:** Support indication of a single TCI state/SRI per TRP in DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP.  |
| [NTT DOCOMO, 20] | * **For multi-PDSCH/PUSCH scheduling with a single DCI for multi-TRP, support indication of single TCI state/SRI for each TRP.**
 |
| [Xiaomi, 21] | ***Proposal 2: Support only one TCI state/SRI in a single DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP.*** |
| [Convida, 22] | ***Proposal 2: Legacy TCI state indication can be extended for single DCI scheduling multi-PDSCH for NR from 52.6 GHz to 71 GHz if gap symbol(s) is considered****.*  |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 7.1 | Introduce multiple TCI states for multi-PDSCHs and multiple SRIs for multi-PUSCHs | **Yes:** vivo, Spreadtrum, Sony, Lenovo/MotM, Samsung, CATT, ZTE/Sanechips, Ericsson, OPPO, LGE, Convida* [Samsung]: Support TCI state/SRI indication rule for multi- PDSCH/PUSCH scheduled by a single DCI for multi-TRP, which has the same approach as the QCL assumptions of single-DCI based multi-TRP operation with inter-slot PDSCH repetition.
* [ZTE/Sanechips]: Proposal 6: For multiple PDSCHs/PUSCHs scheduled by a single DCI, for multi-TRP, support only a single TCI/SRI field in the DCI.
	+ For M-DCI scheme, a single TCI state is indicated by the field for one TRP
	+ For S-DCI scheme, one or two TCI states in a codepoint are indicated by the field for TRPs

**No:** Huawei/HiSi, IDCC, Nokia/NSB, MediaTek, Intel, NTT Docomo, Xiaomi* [Intel]: Support indication of a single TCI state/SRI per TRP in DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP.
* [Xiaomi]: Support only one TCI state/SRI in a single DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP.
 |

### 1st round discussion

#### Observation 7

No clear majority was observed. While 10 companies indicated support of single TCI state for multi-PDSCH/PUSCH, 13 companies indicated supporting extension of Rel-16 TCI state indication mechanism for multi-TRP.

Please share your views on whether/how to support multiple TCI states/SRIs for multi-TRP operation.

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

#### Proposal 7

TBU

# **Beam Management for Shared Spectrum Operation**

## Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | ***Proposal 7: In order to mitigate the impact of LBT failure in BFD procedure, support transmitting complementary aperiodic CSI-RS when LBT failure occurs on periodic BFD-RS.*** |
| [Spreadtrum, 3] | ***Proposal 5: Aperiodic CSI-RS should be a complement for BFD-RS.*** |
| [InterDigital, 4] | ***Observation 7:*** *Absence of periodic/semi-persistent RSs may impact on performance of fine time/frequency tracking, beam failure recovery and beam/CSI reporting.****Proposal 9:*** *Introduce an enhanced mechanism to patch non-transmitted periodic/semi-persistent RSs due to LBT failures.****Proposal 10:*** *Support RS transmission based on candidate RSs when LBT fails for periodic/semi-persistent RSs.****Proposal 11:*** *Support RS pre-emption based on gNB indication to achieve accurate fine time/frequency tracking, beam failure recovery and beam/CSI.* |
| [Sony, 5] | **Proposal 3 : Support aperiodic CSI-RS for beam failure detection (BFD) and candidate beam determination (CBD) at least for unlicensed band operation.****Proposal 7 : Study and specify if needed single DCI scheduled multiple aperiodic CSI-RS and/or aperiodic SRS across multiple slots.** |
| [Lenovo/MotM, 6] | ***Proposal 6: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, the following potential enhancements related to periodic transmissions of RS such as P-TRS should be specified to deal with LBT failure:**** ***Termination of periodic RS transmission on beams where consecutive LBT failures are encountered***
* ***Dynamic switching of the QCL assumption (beams) for periodic RS transmission where consecutive LBT failures are encountered, where:***
	+ ***Multiple QCL assumptions (multiple beams) can be configured to the RS resource and beam switch can be triggered once the continuous number of LBT failures reach a certain threshold value***
 |
| [Samsung, 7] | **Proposal 9: Support multi-slot aperiodic CSI-RS/SRS scheduled by a single DCI for beam management in 60 GHz unlicensed band.****Proposal 10: Further investigate the issue on the uncertainty of RS transmission due to LBT for 60 GHz unlicensed band.** |
| [CATT, 8] | **Observation 1: When UE cannot measure the periodic CSI-RS at the scheduled transmission instance for beam management due to LBT failure, gNB could transmit aperiodic CSI-RS and indicate to the UE as the alternative measurement.** **Proposal 1:** **Aperiodic CSI-RS could be used as the alternative solution of missed L1 RSRP measurement of periodic CSI-RS due to LBT failure with little specification change.**  |
| [ZTE/Sanechips, 9] | **Proposal 7:****Study and evaluate the impact of LBT and the limitation of COT length on the procedure of beam failure detection.** |
| [Ericsson, 10] | **Proposal 10 Enhancement of existing BFD procedures by introduction of ap-CSI-RS is not needed for operation in shared spectrum. The existing BFI counter and timer can be adjusted to compensate for occasional LBT failure causing a missing instance (period) of a periodic BFD RS (SS/PBCH block and/or p-CSI-RS).****Proposal 11 Enhancement of the number of explicitly configured RSs for BFD (SS/PBCH blocks and/or p-CSI-RS) is not needed.****Proposal 12 For the new beam identification (NBI) procedure, the 28 symbol window for decoding PDCCH in recoverySearchSpaceId may need to be revisited for the case that a serving cell is configured with 480 or 960 kHz SCS.** |
| [FUTUREWEI, 11] | ***Proposal 5: Utilize aperiodic CSI-RS transmission to address impact of LBT failure on periodic RS transmissions intended to support beam failure recovery.*** ***Proposal 6: Consider support for low latency beam (QCL-TypeD) switch of periodic RS transmissions after persistent or sustained LBT failure.***  |
| [Nokia/NSB, 12] | ***Observation 3****: For P-TRS transmissions in the cell, it would be beneficial to have a mechanism to be able to transmit P-TRSs dropped due to LBT failure.****Proposal 6:*** *Consider solutions to provide robustness for TRS transmission due to LBT failures, for instance:** *A beam specific (SSB specific) aperiodic TRS transmission that could be triggered for one or multiple UEs at a time to “patch” non-transmitted P-TRS using certain beam (certain SSB as QCL-TypeD source)*
* *Multiple transmission opportunities for the P-TRS within a time period*

***Observation 5:*** *More transmission opportunities for the BFD-RS against LBT failures can be supported by the same mechanism used for peridic CSI-RS such as TRS.****Proposal 7:*** *In case of directional LBT (if applied), consider impacts on beam management in the COT, e.g.* * *impact on validity of the configured DL RSs for L1-RSRP measurement and reporting and*
* *impact on beam switching application time within the COT (e.g. the case when the new beam is or is not QCLed with the LBT beam of the COT).*

***Observation 6:*** *Support of multi-slot CSI-RS can be provided by having a slot offset (could reuse the parameter CSI-ResourcePeriodicityAndOffset currently applicable only for periodic and semi-persistent resource) parameter for the aperiodic CSI-RS resource where the offset would be calculated from the slot where the first CSI-RS resource of the same set is allocated.* |
| [NEC, 13] | ***Proposal 4:*** ***If the indicated beam in the DCI scheduling the PDSCH is QCLed with the directional LBT beam for the DCI, then no additional LBT is needed for the PDSCHs have scheduling offset equal to or greater than timeDurationForQCL in shared spectrum.*** |
| [OPPO, 14] | **Proposal 4: holding the discussion on AP-CSI-RS for BFR/BFD until the LBT procedure has been made clear in agenda item 8.2.6.** |
| [Qualcomm, 15] | **Proposal 4: Support partial BFR for single TRP.** |
| [LG Electronics, 16] | **Proposal #4: The following aspects can be considered to enhance beam management operation when channel access scheme is used for unlicensed spectrum.*** + **How to provide more opportunities of CSI-RS or SRS transmission considering LBT failure**
	+ **How to enhance beam failure procedure considering not transmitted BFD-RS due to LBT failure**
 |
| [MediaTek, 17] | **Proposal 6: The feasibility of AP-CSI-RS triggering for accommodating the periodic CSI-RS transmission prevented by LBT failure needs to be studied when the gap between DCI and the triggered AP-CSI-RS is smaller than the threshold *beamSwitchTiming*.****Proposal 7: The feasibility of increasing periodic RS transmission occasion for accommodating the periodic CSI-RS transmission prevented by LBT failure needs to be studied with respect to the minimization of resource and impact on measurement procedure when more measurements on missing RS due to LBT failure.** |
| [Intel, 18] | **Proposal 6:** No special handling of periodic RS transmissions is needed to address interruptions due to LBT failure as well as no special means are needed to distinguish between LBT failures and beam failures. |
| [NTT DOCOMO, 20] | Proposal 4: Beam failure detection/recovery procedure in NR 52.6-71GHz can consider following potential enhancements,* **whether to increase the number of candidate beams included in set**
* **whether to introduce a new time gap to apply new beam configuration after receiving BFR response from gNB**
* **whether to introduce aperiodic RS monitoring for beam failure detection**
 |
| [Xiaomi, 21] | ***Proposal 3: Aperiodic RS transmission can be triggered to patch a non-transmitted periodic CSI-RS.******Proposal 4: To support more beams, the maximal number of reference singles in one CSI-RS resource set should be increased. Or, multiple aperiodic CSI-RS resource sets associated with one aperiodic trigger state should be allowed to be used for beam measurement.******Proposal 7: The beam failure detection procedure should be enhanced if triggering aperiodic CSI-RS to complement the non-transmitted BFD-RS is supported.*** |
| [Convida, 22] | ***Proposal 3: Enhancement of beam operation for unlicensed bands should be investigated to mitigate interference and optimize system performance due to hidden node for NR from 52.6 GHz to 71 GHz*** |

## Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 9.1 | Whether to enhance RS transmissions to deal with LBT failure | **Yes:** Huawei/HiSi, Spreadtrum, IDCC, Sony, FUTUREWEI, Nokia/NSB, LGE, NTT Docomo, Xiaomi* [IDCC]: Support RS pre-emption based on gNB indication to achieve accurate fine time/frequency tracking, beam failure recovery and beam/CSI.
* [Lenovo/MotM]: For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, the following potential enhancements related to periodic transmissions of RS such as P-TRS should be specified to deal with LBT failure:
	+ Termination of periodic RS transmission on beams where consecutive LBT failures are encountered
	+ Dynamic switching of the QCL assumption (beams) for periodic RS transmission where consecutive LBT failures are encountered, where:
		- Multiple QCL assumptions (multiple beams) can be configured to the RS resource and beam switch can be triggered once the continuous number of LBT failures reach a certain threshold value

**Need further study/hold the discussion:** Samsung, ZTE/Sanechips, OPPO* [Samsung]: Further investigate the issue on the uncertainty of RS transmission due to LBT for 60 GHz unlicensed band.
* [ZTE/Sanechips]: Study and evaluate the impact of LBT and the limitation of COT length on the procedure of beam failure detection.

**No:** CATT, Ericsson, Intel* [CATT]: Aperiodic CSI-RS could be used as the alternative solution of missed L1 RSRP measurement of periodic CSI-RS due to LBT failure with little specification change.
* [Ericsson]: Enhancement of existing BFD procedures by introduction of ap-CSI-RS is not needed for operation in shared spectrum. The existing BFI counter and timer can be adjusted to compensate for occasional LBT failure causing a missing instance (period) of a periodic BFD RS (SS/PBCH block and/or p-CSI-RS).
* [Intel]: No special handling of periodic RS transmissions is needed to address interruptions due to LBT failure as well as no special means are needed to distinguish between LBT failures and beam failures
 |
| 9.2 | Multi-slot aperiodic RS | **Yes:** Samsung, Nokia/NSB, LGE, Xiaomi* [Samsung]: Support multi-slot aperiodic CSI-RS/SRS scheduled by a single DCI for beam management in 60 GHz unlicensed band.
* [LGE]: How to provide more opportunities of CSI-RS or SRS transmission considering LBT failure
 |
| 9.3 | Other enhancements related to beam failure recovery | **Symbol window for decoding PDCCH in recoverySearhSpaceId*** [Ericsson]: For the new beam identification (NBI) procedure, the 28 symbol window for decoding PDCCH in recoverySearchSpaceId may need to be revisited for the case that a serving cell is configured with 480 or 960 kHz SCS.
* [NTT Docomo]: whether to introduce a new time gap to apply new beam configuration after receiving BFR response from gNB

**Partial BFR*** [Qualcomm]: Support partial BFR for single TRP.

**Increased number of candidate beams*** [NTT Docomo]: whether to increase the number of candidate beams included in set
 |

## 1st round discussion

### Observation 8

It is observed that majority of companies (11 companies) indicated support of BFR enhancement or RS enhancement to deal with LBT failure while 7 companies indicated further study and no support. However, no clear majority proposal was observed from the indicated supports from 11 companies.

Please share your views on whether/how to support BFR enhancement or RS enhancement to deal with LBT failure.

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

### Proposal 8

TBU

# **Others**

## Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Sony, 5] | Proposal 8 : Beam alignment during initial access procedure should be considered for NR above 52.6 GHz. |
| [Lenovo/MotM, 6] | ***Proposal 5: For NR operation between 52.6 GHz and 71 GHz with high subcarrier spacing values such as 480kHz and 960kHz, if a UE is going to transmit a set of consecutive PUSCH transmissions including both dynamically scheduled PUSCH transmissions and CG-PUSCH transmissions, the UE can select the latest indicated UL Tx beam to transmit the consecutive UL CG and DG transmissions******Proposal 7: For NR operation between 52.6 GHz and 71 GHz, Rel-17 common TCI state indication should be supported for multi-PDSCH scheduling******Observation 2: For NR operation between 52.6 GHz and 71 GHz, the new indicated common TCI state may not be applicable for the scheduled PDSCHs even the PDSCHs are received after the application time when the UE cannot switch it RX beams to the new indicated common TCI state between two continuous PDSCH transmissions*** ***Proposal 8: For NR operation between 52.6 GHz and 71 GHz, how to determine the applied TCI state for the multiple PDSCH in continuous slots when the indicated common TCI state is changed but the UE cannot switch it RX beam within the CP should be further discussed******Proposal 9: For NR operation between 52.6 GHz and 71 GHz, when multiple PDSCHs with different TBs are scheduled by the DCI indicating a common TCI******state, the ACK/NACK of any one scheduled PDSCH can be used as the ACK for the DCI*** |
| [CATT, 8] | **Proposal 2: The beam management frame work should be reused for NR operation in 52.6-71 GHz.** **Proposal 8: In initial access, the beam adaptation for Msg3 and Msg4 transmission can be adapted based on the beam measurement report from UE.** |
| [Qualcomm, 15] | **Proposal 5: Support UE report of recommended SSB in Msg3/A in initial access.****Proposal 6: Support dynamic beam update of periodic channel/RS.****Proposal 7: Investigate sub-band based beam report.****Proposal 8: The contents of configured TCI states can be dynamically updated*.**** **The contents may include any QCL source RS ID, e.g. both TypeA/D RS IDs, and corresponding BWP/CC ID.**
 |
| [Apple, 19] | **Proposal 3: Consider a mechanism to enable/disable the PDCCH monitoring within the multi-PDSCH duration to improve resource efficiency.**  |
| [NTT DOCOMO, 20] | Proposal 3: For beam management in 52.6-71GHz, discuss the following:* **whether to increase the number of configured CSI-RS resources for beam management.**
* **whether to support reporting more than 4 beams for beam reporting in one report instance, if the number of configured CSI-RS resources in a resource set for beam management is increased.**
 |
| [Xiaomi, 21] | ***Proposal 4: To support more beams, the maximal number of reference singles in one CSI-RS resource set should be increased. Or, multiple aperiodic CSI-RS resource sets associated with one aperiodic trigger state should be allowed to be used for beam measurement.******Proposal 5: An implicit or explicit way to indicate UE the report method, which refers to reporting the measurement results separately or jointly, is needed when multiple aperiodic CSI-RS resource sets are triggered by single DCI for beam measurement.******Observation 1: There is a limitation on the number of periodic CSI-RS resource used for beam measurement in Rel15/16.******Proposal 6: Some enhancements are needed to deal with this limitation if the number of beams more than maxNrofNZP-CSI-RS-ResourcesPerSet are expected to be used in 52.6-71GHz.*** |
| [Convida, 22] | ***Proposal 1: Rel-17 FeMIMO unified TCI framework like TCI state indication for PDCCH can be considered for NR from 52.6 GHz to 71 GHz****.* |

## 1st round discussion

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 11.1 | Beam reporting/alignment during initial access procedure | **Yes:** Sony, CATT, Qualcomm**No:** |
| 11.2 | Dynamic beam update | **Yes:** Lenovo/MotM, Qualcomm, NTT Docomo**No:** |
| 11.3 | Increase the number of configured CSI-RS resources | **Yes:** NTT Docomo, Xiaomi |

### Observation 9

No clear majority was observed. Companies are requested to share their views on the proposals from the companies.

|  |  |
| --- | --- |
| **Company** | **Input** |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

### Proposal 9

TBU

# **References**

1. R1-2106445, “Discussion on the beam management procedures for 52-71GHz spectrum,” Huawei, HiSilicon,
2. R1-2106582, “Discussions on beam management for new SCSs for NR operation from 52.6GHz to 71GHz,” vivo,
3. R1-2106694, “Discussion on beam management for above 52.6GHz,” Spreadtrum Communications,
4. R1-2106769, “Discussions on beam management for new SCSs,” InterDigital, Inc.,
5. R1-2106798, “Beam management enhancement for NR from 52.6GHz to 71GHz,” Sony,
6. R1-2106834, “Beam-management enhancements for NR from 52.6 GHz to 71GHz,” Lenovo, Motorola Mobility,
7. R1-2106876, “Beam management for new SCSs for NR from 52.6 GHz to 71 GHz,” Samsung,
8. R1-2106959, “Beam management for new SCSs for up to 71GHz operation,” CATT,
9. R1-2107003, “Discussion on the beam management for 52.6 to 71GHz,” ZTE, Sanechips,
10. R1-2107053, “Beam Management for New SCSs,” Ericsson,
11. R1-2107101, “Views on Beam management for beyond B52.6 GHz,” FUTUREWEI,
12. R1-2107107, “Beam Management Aspects,” Nokia, Nokia Shanghai Bell,
13. R1-2107155, “Beam management enhancement for NR from 52.6GHz to 71GHz,” NEC,
14. R1-2107240, “Discussion on beam management for new SCSs,” OPPO,
15. R1-2107333, “Beam managment for new SCS,” Qualcomm Incorporated,
16. R1-2107438, “Enhancements for beam management to support NR above 52.6 GHz,” LG Electronics,
17. R1-2107511, “Beam management discussion for 52.6-71 GHz NR operation,” MediaTek Inc.,
18. R1-2107580, “Discussion on Beam management aspects for extending NR up to 71 GHz,” Intel Corporation,
19. R1-2107729, “Beam Management for New SCSs,” Apple,
20. R1-2107848, “Beam based operation for new SCSs for NR from 52.6 to 71 GHz,” NTT DOCOMO, INC.,
21. R1-2107914, “Discussion on beam management for new SCSs,” Xiaomi,
22. R1-2108016, “On Beam Management for NR from 52.6 GHz to 71 GHz,” Convida Wireless.