**3GPP TSG RAN WG1 #104b-e R1-210xxxx**

**e-Meeting, April 12th – 20th, 2021**

**Agenda Item: 8.2.4**

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

**Title: Discussion Summary #1 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#104b-e.

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

## Supported values of beamSwitchTiming, beamReportTiming and timeDurationForQCL

### Observations and Proposals from Contributions

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| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | For 480 kHz SCS (960 kHz SCS), the supported values of “beamSwitchTiming”, “beamReportTiming” and “timeDurationForQCL” are obtained by multiplying a factor of four (eight) to their corresponding values for 120 kHz SCS. |
| [Oppo, 2] | adopt the following beam switch time for 120kHz, 480kHz and 960kHz. FFS for panel activation timing.   |  |  | | --- | --- | | SCS | Beam switch time (symbol) | | 120kHz | 14, 28, 48 | | 480kHz | 56, 112, 192 | | 960kHz | 56, 112, 192 |   adopt the following time duration QCL for 120kHz, 480kHz and 960kHz.   |  |  | | --- | --- | | SCS | Time duration QCL (symbol) | | 120kHz | 14, 28 | | 480kHz | 56, 112 | | 960kHz | 112, 224 |   adopt the following beam report timing for 120kHz, 480kHz and 960kHz.   |  |  | | --- | --- | | SCS | Beam report timing (symbol) | | 120kHz | 14, 28, 56 | | 480kHz | 56, 112, 224 | | 960kHz | 112, 224, 448 | |
| [Spreadtrum, 3] | adopt the following values of parameters “timeDurationForQCL”, “beamSwitchTiming” and “beamReportTiming” for 480 kHz and 960 kHz.   |  |  |  | | --- | --- | --- | |  | 480kHz | 960kHz | | timeDurationForQCL (symbol) | 56, 112 | 56, 112 | | beamSwitchTiming (symbol) | 112, 224, 336 | 112, 224, 336 | | beamReportTiming (symbol) | 56, 112, 224 | 112, 224, 448 | |
| [vivo, 4] | To determine the processing timing of new numerology, it is preferred to introduce a factor to scale reference values of 120kHz. |
| [Nokia/NSB, 5] | Define parameter values (UE capabilities) for the timeDurationForQCL for the PDSCH scheduling for 480 kHz and 960 kHz SCS and values should be: first value: ≤ 56 symbols (≤ 4 slots) and second value: ≤ 112 symbols (≤ 8 slots) with 480 kHz SCSfirst value: ≤ 112 symbols (≤ 8 slots) and second value: ≤ 224 symbols (≤ 16 slots) with 960 kHz SCS Define parameter values (UE capabilities) for the beamSwitchTiming for the A-CSI-RS triggering for 480 kHz and 960 kHz SCS and values should be {≤ 56 symbols/4 slots, ≤112 symbols/8 slots, ≤192 symbols, ≤64 slots, ≤96 slots) with 480 kHz SCS{≤ 112 symbols/8 slots, ≤224 symbols/16 slots, ≤384 symbols, ≤128 slots, ≤192 slots) with 960 kHz SCS Define parameter values (UE capabilities) for the beamReportTiming for 480 kHz and 960 kHz SCS and values should be: {≤ 56 symbols/4 slots, ≤112 symbols/8 slots, ≤224 symbols/16 slots} with 480 kHz SCS{≤ 112 symbols/8 slots, ≤224 symbols/16 slots, ≤448 symbols/32 slots} with 960 kHz SCS |
| [CATT, 6] | The number of symbols for the timeDurationForQCL and beamReportTiming parameter for 480 kHz and 960 kHz SCS should increase in proportion comparing to that of reference lower SCS, e.g., 120 kHz SCS.  For 480 kHz and 960 kHz SCS, the number of symbols for part of beamSwitchTiming values should be increased, and the number of symbols for beamSwitchTiming-r16 can be reused. |
| [Futurewei, 8] | For 480 kHz SCS and 960 kHz SCS, the values of “timeDurationForQCL”, “beamReportTiming” and “beamSwitchTiming”, are obtained by scaling their corresponding values for 120 kHz SCS by 4 and 8, respectively. |
| [Ericsson, 9] | As a starting point for discussion of the UE capabilities, timeDurationForQCL and beamSwitchTiming, an upper bound is given by the FR2 values scaled by 4 or 8 depending on if 480 or 960 kHz SCS is used. Further discuss if this upper bound can be tightened. For the scaled capability values for beamSwitchTiming corresponding to the 224 and 336 OS values from FR2, further discuss supporting finer granularity capability indication for 480 and 960 kHz SCS.  As a starting point for discussion of the value of the additional beam switching delay for cross-carrier triggering of aperiodic CSI-RS on carriers with different numerologies, consider d = 8 and 14 for µPDCCH = 3 and 5, respectively. |
| [Intel, 12] | Modify the following RRC parameters to account UE capabilities for beam management with updated values corresponding to SCS 480 kHz and 960 kHz: for timeDurationQCL: Candidate value set for 480 kHz is {28, 56, 112} OFDM symbols, candidate value set for 960 kHz, {56, 112} OFDM symbols;for beamReportTiming: Candidate value set for 480 kHz is {56, 112, 224} OFDM symbols, candidate value set for 960 kHz, {112, 224, 448} OFDM symbols;for beamSwitchTiming: Candidate value set for 480 kHz and 960 kHz is {112, 224, 336, 672} OFDM symbols; |
| [Apple, 13] | Reuse the absolute time duration defined for 120kHz SCS for new SCSs (i.e., scaling up 4/8 times for 480kHz and 960kHz SCS respectively): timeDurationForQCLbeamSwitchTimingbeamReportTiming |
| [Qualcomm, 14] | For UE capability on the following parameters per new SCS, consider as baseline to use values proportionally scaled by from values for 120kHz SCS timeDurationForQCL, beamSwitchTiming, beamReportTiming, maxNumberRxTxBeamSwitchDL. |
| [Samsung, 15] | The baseline of new beam-related UE capabilities for new SCSs can be obtained by multiplying a factor to the value for 120 kHz SCSs, while keeping same or low time duration as 120 kHz. |
| [Sony, 16] | 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. |
| [LGE, 17] | When new values for timeDurationForQCL, beamSwitchTiming, and beamReportTiming are defined for 480 kHz and 960 kHz SCSs, use the absolute time duration for 120 kHz SCS as the upper bound, and reduce the absolute time durations from the upper bound if feasible. |
| [InterDigital, 19] | 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.  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.  Maintain absolute time durations of timing and timeline associated parameter values in FR2 with 120 kHz SCS for timing and timeline parameter values for NR in 52.6 – 71 GHz.  Whether to support reduced absolute time durations for timing and timeline parameters should be carefully studied. |
| [ZTE/Sanechips, 20] | For NR operation in 52.6 ~ 71 GHz, it can reuse the definition of timeDurationForQCL defined in TS 38.306 and adopt scaled values of reference SCS 120 kHz for new SCSs 480/960 kHz as follows.   |  |  | | --- | --- | | Subcarrier spacing | Proposed value of *timeDurationForQCL*  (symbols) | | 120 kHz | 14, 28 | | 480 kHz | 56, 112 | | 960 kHz | 112, 224 |   For NR operation in 52.6 ~ 71 GHz, it can reuse the definition of beamReportTiming defined in TS 38.306 and adopt scaled values of reference SCS 120 kHz for new SCSs 480/960 kHz as follows.   |  |  | | --- | --- | | Subcarrier spacing | Proposed value of beamReportTiming  (symbols) | | 120 kHz | 14, 28, 56 | | 480 kHz | 56, 112, 224 | | 960 kHz | 112, 224, 448 |   For NR operation in 52.6 ~ 71 GHz, it can reuse the definition of beamSwitchTiming defined in TS 38.306 and adopt scaled values of reference SCS 60/120 kHz for new SCSs 480/960 kHz as follows.   |  |  | | --- | --- | | Subcarrier spacing | Proposed value of *beamSwitchTiming*  (symbols) | | 120 kHz | 14, 28, 48, 224, 336 | | 480 kHz | 56, 112, 192, 896, [1344] | | 960 kHz | 56, 112, 192, 896, [1344] | |

### Summary of views

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| **#** | **Issue** | **Companies’ views** |
| 1.1 | Candidate values of beamSwitchTiming, beamReportTiming and timeDurationForQCL for 120 kHz | beamSwitchTiming   * Reuse the existing values (i.e., 14, 28, 48, 224 and 336 symbols)   + [Spreadtrum], [Nokia/NSB], [Futurewei], [Ericsson], [Intel], [Apple], [Qualcomm], [Samsung], [Sony], [LGE], IDCC, ZTE/Sanechips * Define different values (e.g., some of the existing values)   + Oppo (14, 28, 48),   timeDurationForQCL   * Reuse the existing values (14 and 28 symbols)   + Oppo, [Spreadtrum], [Nokia/NSB], [Futurewei], [Ericsson], [Intel], [Apple], [Qualcomm], [Samsung], [Sony], [LGE], IDCC, ZTE/Sanechips   beamReportTiming   * Reuse the existing values (14, 28 and 56 symbols)   + Oppo, [Spreadtrum], [Nokia/NSB], [Futurewei], [Ericsson], [Intel], [Apple], [Qualcomm], [Samsung], [Sony], [LGE], IDCC, ZTE/Sanechips   Note: Supporting companies with brackets are used when the companies are assuming that they are reusing the existing values for 120 kHz in FR2 for NR in 52.6 – 71 GHz without explicit proposals. |
| 1.2 | Candidate values of beamSwitchTiming for 480 kHz and 960 kHz | Identical absolute time duration (multiplying a factor of four or eight to the corresponding candidate values for 120 kHz SCS)   * Huawei/HiSi, Oppo (480 kHz), Nokia/NSB, Futurewei, Ericsson, Apple, Qualcomm, Samsung, Sony, LGE, IDCC, ZTE/Sanechips   Use candidate values which are obtained by multiply a factor of four to the corresponding values for 120 kHz SCS for 960 kHz   * Oppo, Spreadtrum   Define different values   * Intel (112, 224, 336, 672 for 480/960 kHz) |
| 1.3 | Candidate values of beam ReportTiming for 480 kHz and 960 kHz | Identical absolute time duration (multiplying a factor of four or eight to the corresponding candidate values for 120 kHz SCS)   * Huawei/HiSi, Oppo, Nokia/NSB, Futurewei, Ericsson, Intel, Apple, Qualcomm, Samsung, Sony, LGE, IDCC, ZTE/Sanechips   Define different values   * Intel (56, 112 for 480 kHz and 112, 224, 448 for 960 kHz) |
| 1.4 | Candidate values of timeDurationForQCL for 480 kHz and 960 kHz | Identical absolute time duration (multiplying a factor of four (eight) to the corresponding values for 120 kHz SCS)   * Huawei/HiSi, Oppo, Spreadtrum (480 kHz), Nokia/NSB, Futurewei, Ericsson, Apple, Qualcomm, Samsung, Sony, LGE, IDCC, ZTE/Sanechips   Use candidate values which are obtained by multiply a factor of four to the corresponding values for 120 kHz SCS for 960 kHz   * Spreadtrum   Define different values   * Intel (28, 56, 112 for 480kHz and 56, 112 for 960 kHz) |
| 1.5 | Signaling method to indicate values of beamSwitchTiming, beamReportTiming and timeDurationForQCL | Absolute values in number of symbols   * [Oppo], [Spreadtrum], [Nokia/NSB], [Futurewei], [Ericsson], [Intel], [Apple], [Qualcomm], [Sony], [LGE], [IDCC], [ZTE/Sanechips]   Multiply a factor to the corresponding values of 120 kHz (e.g., 4 for 480 kHz and 8 for 960 kHz)   * Huawei/HiSi, vivo   Note: Supporting companies with brackets are used when the companies are providing proposals based on absolute values in number of symbols without explicit proposals. |

### 1st round discussion

#### Observation 1

For timeDurationForQCL, beamSwitchTiming and beamReportTiming, it is observed that majority of companies are supporting reusing the existing candidate values for 120 kHz in NR 52.6 – 71 GHz. In addition, majority of companies are supporting identical absolute time duration for 480 kHz and 960 kHz (i.e., multiplying a factor of four or eight to the corresponding candidate values for 120 kHz SCS). For a signaling method, two candidate methods (indicating number of symbols or introducing scaling fators) are discussed. Companies are encouraged to share their views on the signaling method.

#### Proposal 1

* For timeDurationForQCL, beamSwitchTiming and beamReportTiming,
  + Following candidate values of FR2 are reused for 120 kHz:
    - timeDurationForQCL: 14 and 28 symbols
    - beamSwitchTiming: 14, 28, 48, 224 and 336 symbols
    - beamReportTiming: 14, 28 and 56 symbols
  + Reuse the absolute time duration defined for 120kHz for 480 kHz and 960 kHz
    - Down select one of the following alternatives for UE capability indication method
      * Alt-1: UE reports preferred values in number of symbols
      * Alt-2: Introduce a factor to scale the reference values of 120kHz

#### Proposal 1a (updated during GTW session)

Proposal:

For timeDurationForQCL, beamSwitchTiming and beamReportTiming,

* Following candidate values of FR2 are reused for 120 kHz:
  + timeDurationForQCL: 14 and 28 symbols
  + beamSwitchTiming: 14, 28, 48, 224 and [336] symbols
  + beamReportTiming: 14, 28 and 56 symbols
* Reuse the absolute time duration defined for 120kHz as the maximum reportable value for 480 kHz and 960 kHz
  + Down select one of the following alternatives for UE capability indication method used to report the values
    - Alt-1: UE reports preferred values in number of symbols
    - Alt-2: Introduce a factor to scale the reference values of 120kHz for 480 kHz and 960 kHz respectively
  + FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced

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| **Company** | **Input** |
| LG Electronics | As discussed in GTW session, our understanding on Alt-1 and Alt-2 is:   * For Alt-1, a UE is allowed to report any combination of candidate values for any SCSs. For example, 28 symbols of timeDurationForQCL for 120 kHz but 56 symbols of timeDurationForQCL for 240 kHz can be reported by the UE. * For Alt-2, once a UE reports a value for 120 kHz, the UE does not need to report any value for 480/960 kHz SCS. For example, if a UE reports 28 symbols of timeDurationForQCL for 120 kHz, then timeDurationForQCL for 480/960 kHz is automatically determined by 112/224 symbols for 480/960 kHz SCS, respectively, without additional capability report for 480/960 kHz.   Even though this is the case, we are not in a hurry to decide UE capability signaling details at this stage. So, we suggest to defer the discussion on signaling details.  Furthermore, one concern during GTW session was that some of values (e.g., 224/336 symbols for beamSwitchTiming) may not be kept as the absolute time duration for 120 kHz.  Based on above observations, we suggest the following modification:  For timeDurationForQCL, beamSwitchTiming and beamReportTiming,   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and 336 symbols   + beamReportTiming: 14, 28 and 56 symbols * Reuse the absolute time duration defined for 120kHz as the maximum reportable value for 480 kHz and 960 kHz, at least for timeDurationForQCL and beamReportTiming   + FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced |
| Ericsson | We agree with LGE that we do not need to decide on UE capability signaling details at this stage. The important thing to agree on is the supported values, or at least a range of the supported values. While we agree that the absolute time duration for 120 kHz is a reasonable starting point for discussion, we think it should be further discussed whether there can be further tightening of these values.  We agree with the general direction of LGE's modified proposal; however, we are a bit unclear on what "maximum reportable value" means. For example, for timeDurationForQCL, the current candidate values for UE capability reporting are 14 and 28. For example, if these are scaled by 4x (for 480 kHz), this results in 56 and 112 symbols. The maximum reportable value would then seem to be 112. So, then is it understood that 56 is supported as well?  An alternative formulation of the proposal would be to agree on supporting at least 14 and 28 scaled by 4x (for 480 kHz), and then further discuss if additional values are supported as well.  We suggest the following:   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and 336 symbols   + beamReportTiming: 14, 28 and 56 symbols * For 480 kHz   + Support at least the candidate values for 120 kHz scaled by 4x   + FFS: Support for additional candidate value(s) * For 960 kHz   + Support at least the candidate values for 120 kHz scaled by 8x   + FFS: Support for additional candidate values(s) * FFS: UE capability signaling details |
| ZTE, Sanechips | We have similar views with LGE and Ericsson that UE capability indication method can be discussed later.  For this proposal from FL, in fact, we are not understand what “ **the maximum reportable value**” means and why it is added herein.  In addition, we would like to further confirm whether all reference values of 120kHz SCS is scaled by a factor to obtain values of 480KHz/960KHz, or only part of all reference values of 120kHz SCS is scaled by a factor to obtain values of 480KHz/960KHz. |
| Sony | Thanks to FL for the nice summary. We would like to share following views.  1) UE capability signaling  Similar with LGE and Ericsson, we also feel that it might be too early to decide signaling method for beam-related UE capability. What is more important is to determine values in symbols for SCS-480kHz and SCS-960kHz. So, the down selection of Alt.1 and Alt.2 can be touched after these UE capability values are settled down.  2) Wording issue  As for the following wording, we also sympathize what Ericsson mentioned and the valid case therein. In other words, for the baseline SCS-120, there could be different values, e.g. 14 and 28 symbols for TimeDurationForQCL. Which absolute time should be used as maximum reportable value for SCS-480kHz or SCS-960kHz seems not clear.   * Reuse the absolute time duration defined for 120kHz as the maximum reportable value for 480 kHz and 960 kHz   By checking Ericsson’s wording, we think that’s fine.  3) beamSwitchTiming  As far as we know, for the UE capability beamSwitchTiming in SCS-120kHz, there are special values, i.e. 224 and 336 symbols which were re-interpreted in Rel.16 for some reason and UE behavior was modified accordingly. As for SCS-480kHz and 960kHz, we think whether these special values should be 4x or 8x from the baseline SCS-120kHz can be FFS. |
| MediaTek | We agree with LGE, Ericsson, and ZTE that the signaling of capability can be discussed later and we also agree with LGE’s observation on some value of beamswitchtiming in 120kHz can’t be directly translate to the value for 480/960kHz. Also, the wording of second main bullet is not clear to us. Which absolute time duration defined for 120 kHz is as the maximum reportable value for 480 kHz and 960kHz? Or does it mean that the absolute time duration for each reportable values for 120kHz can be used to specify the reportable values for 480 kHz and 960kHz? If the intention is later, then we suggest to change the wording to either Ericsson’s wording or the following:   * Reuse the absolute time duration for each reportable value defined for 120kHz ~~as~~ to define the ~~maximum~~ reportable value for 480 kHz and 960 kHz   in addition to the main bullet, Alt-2 is not clear to us. If Alt-2 is supported, does it mean that when a UE signals timeDuraitonForQCL =14 symbols for 120kHz, then the UE can only signal timeDurationforQCL=56 symbol for 480kHz and the UE can’t signal other values? |
| Qualcomm | We are generally fine for Proposal 1a with slight preference to Alt1 to keep the same legacy format. Furthermore, Alt1 works even if 120K is not reported. Also, Alt2 needs to clarify whether it is a single scaling factor for all values or individual scaling factor per value. For the beamSwitchTiming, it might be good to clarify the reason for putting 336 in bracket. |
| vivo | Our preference is to select Alt-2. The important thing is to decide the values for new SCSs in terms of number of symbols. We’re okay to decide the indication/capability reporting later once the values are finalized.  On the suggested wording from Ericsson, seems the original intention of “FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced” is not captured in “FFS: Support for additional candidate value(s).” So we suggest to revise the 2nd subullet for 480 and 960 kHz into “FFS: Support for additional candidate(s) with smaller value”. Alternatively, we’re also okay with MediaTek’s wording.  Whether we further reduce absolute time duration for 480 and 960 kHz SCS, we think there’s another aspect need to be discussed. So we suggest add another FFS: how to reduce UE data buffer complexity.  Taking operation of default beam in case of 960kHz for example, UE would buffer 8 times of I/Q data comparing to 120kHz during default beam duration. In order to reduce UE buffer capability, there are some potential options to be discussed.   * Option1: shorten the time duration for default beam. * Option2: keep same absolute time duration as 120kHz, but introduce a signaling to inform an expected start time of for data buffer or default beam reception. |
| CATT | In principle OK with the proposal, but for better wording we prefer Ericsson’s version. For signalling we would prefer alt1. |
| Intel | We are fine with the 1st main bullet.  For the 2nd main bullet some clarifications are needed.  First, which absolute time duration of SCS 120 kHz is used as the max reportable value for 480 kHz / 960 kHz. We assume that the maximal absolute time duration of SCS 120 kHz is also the max for SCS 480 kHz / 960 kHz.  Second is regarding the value of the scaling factor in Alt-2. We assume that the scaling is according to the scaling of SCS, i.e., the value of 4 is for SCS 480 kHz and 8 is for 960 kHz. |
| Futurewei | We prefer to use Ericsson’s alternate formulation. We prefer to define baseline sets of supported values for timeDurationForQCL, beamSwitchTiming and beamReportTiming, respectively. (i) For 120kHz SCS the baseline sets retain all respective candidate values supported in FR2. (ii) For 480 kHz the baseline sets of values for 120 kHz are each scaled by 4. (iii) For 960 kHz the baseline sets of values for 120 kHz are each scaled by 8.  Additional enhancement to the baseline sets for 480 and 960 kHz in terms of including more values is FFS. |
| Samsung | We are generally fine with Proposal 1a. We are ok with reusing FR2 120kHz values and the absolute time duration for 120 kHz as the upper bound for 480 kHz and 960 kHz.  Regarding UE capability indication method for reporting values, we agree with LGE and Ericsson that the method is not needed to be decided at this stage. |
| DOCOMO | We are fine with the proposal but suggest following wording modification to make it clearer:  Proposal:  For timeDurationForQCL, beamSwitchTiming and beamReportTiming,   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and [336] symbols   + beamReportTiming: 14, 28 and 56 symbols * Reuse the absolute time duration defined for 120kHz as the maximum reportable value for 480 kHz and 960 kHz   + Down select one of the following alternatives for UE capability indication method used to report the values     - Alt-1: UE reports preferred values in number of symbols for 480kHz and 960kHz SCS.     - Alt-2: UE doesn’t report values for 480 kHz and 960 kHz SCS. Introduce a factor to scale the reference values of 120kHz to determine values for 480 kHz and 960 kHz respectively   + FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced |
| Xiaomi | We have the same question with Ericsson about “maximum reportable value”. It should be clarified. In addition, the second bullet is about the timing for 480kHz and 960kHz, and the UE capability indication method should be discussed in another bullet.  For timeDurationForQCL, beamSwitchTiming and beamReportTiming,   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and [336] symbols   + beamReportTiming: 14, 28 and 56 symbols * Reuse the absolute time duration defined for 120kHz as the maximum reportable value for 480 kHz and 960 kHz   + FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced * Down select one of the following alternatives for UE capability indication method used to report the values   + Alt-1: UE reports preferred values in number of symbols   + Alt-2: Introduce a factor to scale the reference values of 120kHz for 480 kHz and 960 kHz respectively |
| OPPO | Generally we are fine with reusing FR2 120kHz values for timeDurationForQCL, beamSwitchTiming, and beamReportTiming, except for some special values, i.e., 224 and 336 symbols for beamSwitchTiming. We agree with Sony and prefer to further study these values.  Regarding UE capability indication method for reporting values, we agree with majority of companies that the method is not needed to be decided at this stage. |
| Moderator | Proposal 1b is provided in the below based on the comments from Ericsson and vivo. Please provide your view on Proposal 1b. |

#### Proposal 1b (suggested by Ericsson and vivo)

For timeDurationForQCL, beamSwitchTiming and beamReportTiming,

* Following candidate values of FR2 are reused for 120 kHz:
  + timeDurationForQCL: 14 and 28 symbols
  + beamSwitchTiming: 14, 28, 48, 224 and 336 symbols
  + beamReportTiming: 14, 28 and 56 symbols
* For 480 kHz
  + Support at least the candidate values for 120 kHz scaled by 4x
  + FFS: Support for additional candidate value(s)
* For 960 kHz
  + Support at least the candidate values for 120 kHz scaled by 8x
  + FFS: Support for additional candidate values(s)
* FFS: UE capability signaling details
* FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced

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| **Company** | **Input** |
| LG Electronics | The impression from “FFS: Support for additional candidate value(s)” could be to define multiple values: One is obtained by scaling 4 (or 8) times for 480 (or 960) kHz SCS and the other is additional value. But it may not be the intention of this proposal. If so, we propose to remove “FFS: Support for additional candidate value(s)” at all, since the last FFS can imply we may revisit some of values to make them less than absolute time duration defined for 120 kHz. |
| DOCOMO | We are fine with the proposal. |
| Huawei, HiSilicon | We do not exactly understand the purpose of the last FFS: “Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced”. We have already two FFSs “Support for additional candidate values(s)” for 480k and 960k. This additional candidate values can potentially be smaller than the maximum supported value for each parameter. For instance, an additional value for timeDurationForQCL for 480k may be 28\*4-N (for some positive N>=0) which is smaller than the maximum value of 28\*4 for timeDurationForQCL in 480k. Therefore, the FFSs for 480k and 960k seem to also include the cases that may be covered by the last FFS. Other than that, the last FFS just creates confusion. We suggest to remove it.  Further, our second concern is that the supported additional candidate values should not be less than the minimum supported absolute time in Rel-15/16. The minimum supported time for all three parameters corresponds to 14 symbols in 120 Khz which amounts for 14\*4 and 14\*8 symbols for 480 and 960 kHz respectively. As such, we suggest the following modification based on 1b:  **Modified proposa1 1b:**  For timeDurationForQCL, beamSwitchTiming and beamReportTiming,   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and 336 symbols   + beamReportTiming: 14, 28 and 56 symbols * For 480 kHz   + Support at least the candidate values for 120 kHz scaled by 4x   + FFS: Support for additional candidate value(s) * For 960 kHz   + Support at least the candidate values for 120 kHz scaled by 8x   + FFS: Support for additional candidate values(s) * FFS: UE capability signaling details * Note: If supported, additional candidate values (s) cannot be smaller than 14\*4 and 14\*8 symbols for 480 kHz and 960 kHz, respectively. |
| Spreadtrum | We are fine with the proposal in principle. Regarding some special values e.g. 224 and 336 symbols for beamSwitchTiming, we share the same view as Sony that it need to be further studie. |
| MediaTek | We share a similar view with Huawei,HiSilicon. Our understanding on   * + FFS: Support for additional candidate values(s)   is we are allowed to revisit the available values later on and decide whether larger values can be included. With this understanding, We also suggest to remove the last FFS (although the reasoning might be different from LGE)   * FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced |
| Qualcomm | Suggest to remove last FFS. Additional candidate values are already FFS |
| vivo | Let me clarify our intention.  The last FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced talks about whether to further reduce time (i.e. smaller value than 4x/8x that of 120 kHz). While the sub-bullet under 480 and 960 kHz “FFS: Support for additional candidate values(s)” does not have that meaning and can be interpreted either smaller or larger value. In fact, MediaTek’s comment indicates larger value which we don’t agree. If the last sentence is to be removed, we suggest the following wording.  For timeDurationForQCL, beamSwitchTiming and beamReportTiming,   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and 336 symbols   + beamReportTiming: 14, 28 and 56 symbols * For 480 kHz   + Support at least the candidate values for 120 kHz scaled by 4x   + FFS: Support for additional candidate(s) with smaller value(s) * For 960 kHz   + Support at least the candidate values for 120 kHz scaled by 8x   + FFS: Support for additional candidate(s) with smaller values(s) * FFS: UE capability signaling details |
| Ericsson | We think the note added by Huawei is too restrictive:   * Note: If supported, additional candidate values (s) cannot be smaller than 14\*4 and 14\*8 symbols for 480 kHz and 960 kHz, respectively.   At least our intent for adding the FFS on additional candidate values was to investigate the possibility for a more capable UE to indicate an absolute time that is less than that defined for FR2, i.e., achieve some tightening. It is too early to close the door and say that we can do no better than FR2. We also note that 224 and 336 scaled by 4x and 8x is a very large number of slots.  We agree with vivo's suggested update, with the understanding that we can also discuss adding values in between the 4x or 8x scaled values, e.g., x 56 y 112 where x < 56 and 56 < y < 112. |
| Intel | We’re supportive regarding Proposal 1b.  However, we would like to avoid rather high values for 480 kHz / 960 kHz especially for beamSwitchTiming parameter. For example, direct scaling of 224 and 336 symbols for beamSwitchTiming at SCS 120 kHz results in more than 1000 symbols at SCS 480 kHz / 960 kHz. This may complicate scheduling of A-CSI-RS. Therefore, we would like to suggest slight modification of Proposal 1b as follows:  For timeDurationForQCL, beamSwitchTiming and beamReportTiming,   * Following candidate values of FR2 are reused for 120 kHz:   + timeDurationForQCL: 14 and 28 symbols   + beamSwitchTiming: 14, 28, 48, 224 and 336 symbols   + beamReportTiming: 14, 28 and 56 symbols * For 480 kHz   + Support at least the candidate values for 120 kHz scaled by 4x except for beamSwitchTiming     - FFS: whether all candidate values for beamSwitchTiming for 120 kHz can be scaled   + FFS: Support for additional candidate value(s) * For 960 kHz   + Support at least the candidate values for 120 kHz scaled by 8x except for beamSwitchTiming     - FFS: whether all candidate values for beamSwitchTiming for 120 kHz can be scaled   + FFS: Support for additional candidate values(s) * FFS: UE capability signaling details   FFS: Whether absolute time duration defined for 480 kHz and 960 kHz can be further reduced |
| Futurewei | We are fine with the original 1b proposal but feel the last FFS can be removed. |
| Lenovo, Motorola Mobility | We are fine with the proposal and suggested updates by Intel |

## maxNumberRxTxBeamSwitchDL

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 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.  Consider smaller values for maxNumberRxTxBeamSwitchDL in 480kHz and 60kHz, e.g., 2, 4, 7.  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. |
| [Spreadtrum, 3] | Regarding “maxNumberRxTxBeamSwitchDL”, the number of Tx and Rx beam changes UE can perform should be scale down to {2, 4, 7} within a slot. |
| [Nokia/NSB, 5] | Values for maxNumberRxTxBeamSwitchDL should be ≥2 for both 480 and 960 kHz SCS. |
| [CATT, 6] | 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.  For SCS 480kHz/960Khz, the minimum and maximum available value of maxNumberRxTxBeamSwitchDL should be reduced. |
| [Ericsson, 9] | For 480 and 960 kHz SCS, support a value range of {4,7,14} for the UE capability parameter maxNumberRxTxBeamSwitchDL. |
| [Intel, 12] | for maxNumberRxTxBeamSwitchDL: Candidate value set is {2, 4, 7, 14} switches. |
| [Qualcomm, 14] | For UE capability on the following parameters per new SCS, consider as baseline to use values proportionally scaled by from values for 120kHz SCS timeDurationForQCL, beamSwitchTiming, beamReportTiming, maxNumberRxTxBeamSwitchDL. |
| [Sony, 16] | 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. |
| [InterDigital, 19] | It is preferred to support maxNumberRxTxBeamSwitchDL for higher 480 kHz and 960 kHz as well as 120 kHz. |
| [ZTE/Sanechips, 20] | For NR operation in 52.6 ~ 71 GHz, it can reuse the definition of maxNumberRxTxBeamSwitchDL defined in TS 38.306 and allow the maximum number of Tx and Rx beam changes UE can perform within a slot equals to one or two in addition to [4, 7, 14] for SCSs 480/960 kHz.   |  |  | | --- | --- | | Subcarrier spacing | Proposed value of *maxNumberRxTxBeamSwitchDL* | | 120 kHz | 4, 7, 14 | | 480 kHz | [1], 2, 4, 7, 14 | | 960 kHz | [1], 2, 4, 7, 14 | |
| [Docomo, 21] | For timing parameters associated with beam based operation, New value range for maxNumberRxTxBeamSwitchDL may need to be considered for 480/960kHz SCS based on UE capability. |

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | maxNumberRxTxBeamSwitchDL | Support maxNumberRxTxBeamSwitchDL for new SCSs   * Huawei/HiSi, Spreadtrum, Nokia/NSB, CATT, Ericsson, Intel, Qualcomm, Sony, IDCC, ZTE/Sanechips, Docomo   Proposed candidate values   * Huawei/HiSi (2, 4, 7), Spreadtrum (2, 4, 7), Nokia/NSB (≥2), Ericsson (4, 7, 14), Intel (2, 4, 7, 14), ZTE/Sanechips (2, 4, 7, 14) |

### 1st round discussion

#### Observation 2

For maxNumberRxTxBeamSwitchDL, it is observed that majority of companies are supporting to introduce new candidate values, however, there’s no clear majority view on the candidate values.

#### Proposal 2

* Introduce new parameter values for maxNumberRxTxBeamSwitchDL
* Companies are encouraged to provide preferred values on maxNumberRxTxBeamSwitchDL

|  |  |
| --- | --- |
| **Company** | **Input** |
| LG Electronics | {4,7,14} per slot can be the starting point and we are open to discuss whether 2 is additionally needed or not. |
| Ericsson | We think that already 4 is a small number, e.g., consider a CSI-RS resource set with repetition = on. Being restricted to any less than 4 seems quite limiting. Hence, our preference is to support only the existing values {4,7,14}. |
| ZTE, Sanechips | Considering shorter absolute time of a slot/symbol with SCSs 480/960 kHz, we think smaller value for maxNumberRxTxBeamSwitchDL can be further considered and discussed in addition to {4,7,14} per slot. |
| Sony | Considering the fact that the slot length of SCS-960kHz is 1/8 that of SCS-120kHz, the time allowed for UE to conduct Rx/Tx beam switching would be challenged. For extreme example, assuming the same absolute time used for Rx/Tx beam retuning, if a UE can switch Rx/Tx 4 times within a slot in SCS-120kHz, it can only switch (4/8) times per slot in SCS-960kHz, i.e. two slots to switch one beam.  Along with value {4/7/14}, we suggest RAN1 to consider value {1 and 2}. |
| MediaTek | We agree with ZTE and Sony that smaller value will be needed for 480/960 kHz. maxNumberRxTxBeamSwitchDL is UE capability and UE should be able to pick small value to reflect the implementation limit, if necessary. |
| Qualcomm | We prefer the following candidate values for maxNumberRxTxBeamSwitchDL as starting point  • For 480k: 1, 2, 4  • For 960k: 1, 2 |
| vivo | 1. the value for maxNumberRxTxBeamSwitchDL is related to beam switching gap. For instance, for 960kHz, at least one symbol is reserved for beam switching, so #14 is not suitable for 960kHz. If beam switching gap is based on the reporting of UE capability, the maximum value is subject to the gap value. 2. the design of SSB pattern maybe affect the value. For instance, Ran4 suggest UE should perform measurement about AGC, timing or RSRP of each beam pair based on SSB in a period of SSB burst after TCI states updating for PDSCH by MAC CE, new updating TCI stats associated with different QCL-Type D maybe appears in same slot, UE should finish this operation in this slot. We think the minimum value may be subject to design of SSB pattern. |
| CATT | We prefer {2,4,7} for both 480Khz and 960Khz as in our tdoc. We agree {14} is not suitable for 960Khz |
| Intel | We are supportive regarding moderator’s suggestion. However, we would like to hear about the existing set of values for maxNumberRxTxBeamSwitchDL. Does the suggestion assume that we automatically support the existing set, i.e., {4, 7, 14}, and here just discuss additional values on top of the existing ones?  [Mod] The proposal 2 is just proposing to support maxNumberRxTxBeamSwitchDL and there is no assumption on whether to support the existing set. It needs further discussion. |
| Convida Wireless | We are fine with {4, 7, 14} as baseline. The smaller value than 4 can be further discussed. |
| Futurewei | We prefer to support {4, 7}. Additionally, we believe supported value per-slot of 2 can be considered. |
| Samsung | Our preference is {4,7,14} and we are open to discuss the value ‘2’. |
| DOCOMO | We are open to discuss smaller values, e.g. 2. |
| Xiaomi | Support proposal 2. |
| OPPO | Our preference is:  • For 480k: 2, 4  • For 960k: 2  And we are open to discuss the value ‘1’ for both 480k and 960k. |
| Moderator | It seems that Proposal 2 is acceptable. Please provide more inputs on the values of maxNumberRxTxBeamSwitchDL |
| Huawei, HiSilicon | Our preference is {2, 4, 7}. We are open to discuss 1 as well. In our view, supporting lower number of Rx+Tx beam changes for higher SCSs in Rel-17 is important:   1. Considering the unified TCI framework being discussed in FeMIMO, it is likely to use unified TCI for multiple channels. The unified TCI state is specially useful for channels mapped on adjacent symbols to avoid unnecessary beam switches and reducing the total number of Rx+Tx beam changes in a slot. 2. Allowing frequent beam switching capability is challenging and non-cost effective for UE implementation. We are not sure about the usecase of maxNumberRxTxBeamSwitchDL = 14, that is, changing the beam on every symbol even for 120 KHz.   Last but not least, depending on RAN4 reply on LS from RAN1 [2], beam switching time may be longer than the CP duration at least for 960kHz SCS. This would necessitate the introduction of a beam switching gap which, in turn, would result in reducing the system resource utilization. Note that if one symbol beam switching gap is introduced for 960 KHz, maxNumberRxTxBeamSwitchDL cannot be larger than 7 even in theory. |
| Spreadtrum | Our preference is {2, 4, 7}. Given that the slot/symbol length of 480kHz/960kHz SCS is much smaller than that of 120kHz, it is too stringent for UE to maintain the same numbers of RX+TX beam changes in a slot. |
| MediaTek | At least point, we suggest to include at least {1}. However, it might be better to wait for RAN4’s reply and discuss the other values later. |
| Ericsson | Given companies preferences to add additional values, we can compromise if {4,7,14} are still preserved. Hence, we can be open to support 2 in addition to {4,7,14} even though we think this would lead to quite limited possibilities for UE Rx beam refinement (CSI-RS resource set with repetition = on). An aperiodic CSI-RS resource set is limited to one slot, so a UE capable of only 2 beam switches will require the network to trigger ap-CSI-RS in multiple different slots to achieve Rx beam refinement, thus increasing PDCCH load. |
| Intel | We propose to support existing set of values {4, 7, 14} and additional value of 2 switches per slot to account the reduced slot duration time for SCS 480 kHz / 960 kHz. |
| Futurewei | We are fine with {2,4,7}. We suggest further discussion on {1} being proposed as well as feasibility of {14}. |
| Lenovo, Motorola Mobility | We support the proposal |

## Additional beam switching time delay d

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [vivo, 4] | the issue about UE buffer capability should be considered together with timing determination. |
| [Nokia/NSB, 5] | Additional time delay d is defined when triggering PDCCH with 120kHz or 480kHz has a smaller subcarrier spacing than AP-CSI-RS. Value(s) for new SCSs FFS. |
| [CATT, 6] | Table 1: Additional beam switching timing delay *d*   |  |  | | --- | --- | | **µPDCCH** | **d [PDCCH symbols]** | | 0 | 8 | | 1 | 8 | | 2 | 14 | | 3 | 26 | | 5 | 48 | | 6 | 90 | |
| [Ericsson, 9] | As a starting point for discussion of the value of the additional beam switching delay for cross-carrier triggering of aperiodic CSI-RS on carriers with different numerologies, consider d = 8 and 14 for µPDCCH = 3 and 5, respectively. |
| [Intel, 12] | For additional beam switching delay , support [14] PDCCH symbols when (SCS 120 kHz), support [56] PDCCH symbols when (SCS 480 kHz). |
| [Apple, 13] | Reuse the absolute time defined for 60kHz for Additional beam switching time delay ‘d’, i.e., 28 symbols for 120kHz and 112 symbols for 480kHz. |
| [LGE, 17] | Define UE behaviour to determine different QCL assumptions for triggered aperiodic CSI-RS depending on the offset between PDCCH and CSI-RS, after new values are defined for beamSwitchTiming for 480 kHz and 960 kHz SCSs. | |
| [InterDigital, 19] | It is preferred to support additional beam switching time delay d for both 120 kHz and 480 kHz. |
| [ZTE/Sanechips, 20] | 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 | |
| [Docomo, 21] | For timing parameters associated with beam based operation, 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 | Additional beam switching time delay d | **Yes:** vivo, Nokia/NSB, CATT, Ericsson, Intel, Apple, LGE, IDCC, Docomo  **No:** |
| 3.2 | Proposed candidate values for 120 kHz and 480 kHz | Ericsson (8, 14), Intel (14, 56), Apple (28, 112), ZTE/Sanechips (28, 56) |
| 3.3 | Definition on UE behaviour to determine different QCL assumptions for triggered aperiodic CSI-RS | **Yes:** LGE  **No:** |

### 1st round discussion

#### Observation 3

For additional beam switching time delay d, it is observed that majority of companies are supporting to introduce new candidate values, however, there’s no clear majority view on the candidate values.

#### Proposal 3

* Introduce new parameter values for additional beam switching time delay d for triggering AP-CSI-RS when triggering PDCCH with 120kHz or 480kHz has a smaller subcarrier spacing than AP-CSI-RS
* Companies are encouraged to provide preferred values on additional beam switching time delay d

|  |  |
| --- | --- |
| **Company** | **Input** |
| LG Electronics | Just to clarify our proposal in issue #3-3, it is related to beamSwitchTiming, rather than related to delay *d*. To be specific, in Rel-15/16, different UE behavior was defined depending on whether the offset between PDCCH and CSI-RS is smaller than 48 symbols (i.e., the beam switching threshold) or not. If we define new set of values for beamSwitchTiming (as in Section 2.2), it is also necessary to define beam switching threshold as one of values in the set. |
| Ericsson | Agree with proposal |
| ZTE, Sanechips | Agree with the proposal. We also agree with LGE’s views, but beam switching threshold can be discussed after Section 2.1 has some progress. |
| Sony | Supportive to the FL proposal. |
| Qualcomm | For the d value, we prefer 28 for 120k, and 112 for 480k. |
| vivo | To clarify, our proposal in our contribution is more related to timeline and UE processing, not directly on the additional beam switch delay d itself though.  We share the understanding as LG on the beam switching threshold. |
| CATT | Agree with proposal |
| Intel | We support moderator’s suggestion.  However, we want to clarify that the additional beam switching time delay d is used not only for triggering AP-CSI-RS but also during cross-carrier scheduling in case of scheduling PDCCH has a smaller SCS than the scheduled PDSCH. We assume that the suggestion from moderator automatically covers this case as currently is in NR Rel-15/16.  [Mod] I checked the specification, but I couldn’t find the application of additional beam switching timing delay d for the scheduled PDSCH. Please clarify.  [Intel] TS 38.214, Section 5.1.5  If the PDCCH carrying the scheduling DCI is received on one component carrier, and the PDSCH scheduled by that DCI is on another component carrier:  - The *timeDurationForQCL* is determined based on the subcarrier spacing of the scheduled PDSCH. If µPDCCH < µPDSCH an additional timing delay is added to the *timeDurationForQCL*, where *d* is defined in 5.2.1.5.1a-1, otherwise *d* is zero; |
| Futurewei | We agree with the proposal |
| Samsung | Support the proposal |
| DOCOMO | We are supportive of the proposal. |
| Xiaomi | We are fine with proposal 3. |
| Huawei, HiSilicon | Agree with the proposal. Can accept the minimum value of 28 for 120k, and the minimum value of 112 for 480k. |
| Spreadtrum | We are fine with the proposal |
| MediaTek | We are fine with proposal 3. The value can be discussed later when other scheduling features are stable. |
| Lenovo, Motorola Mobility | We support the proposal |

## Introduction of beam switching time between signals/channels

### Observations and Proposals from Contributions

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| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | At least for 960kHz 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 different beams.  Apply further scheduling restrictions on the adjacent symbol to the signal with a higher priority, when the adjacent symbol carries a signal with a lower priority and using different beams. |
| [vivo, 4] | Supporting the UE capability reporting of beam switching gap and further study P3 beam management. |
| [Nokia/NSB, 5] | No explicit beam switching gap is introduced between DL signals and channels. |
| [CATT, 6] | When the additional beam switching gap is introduced, QCL assumption needs to be investigated. |
| [Futurewei, 8] | For both 480 kHz and 960 kHz SCS, UE is not expected to 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. |
| [Ericsson, 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). |
| [Lenovo/MotM, 11]: | 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.  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. |
| [Intel, 12] | 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. |
| [Qualcomm, 14] | Introduce a minimum interval between start of two consecutive beam switches. The value can be X symbols per SCS and can be UE capability. 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. |
| [Samsung, 15] | Reserve one symbol for beam switching gap when using 480 kHz and 960 kHz SCSs. |
| [ZTE/Sanechips, 20] | 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. |
| [Docomo, 21] | For timing parameters associated with beam based operation, 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** |
| 4.1 | Introduction of beam switching gap | **Yes:** Huawei/HiSi, vivo, CATT, Futurewei, Ericsson, Lenovo/MotM, Qualcomm, Samsung, Docomo   * [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 for **between different SSBs and between CSI-RS resources in a resource set for BM**   **No:** Nokia/NSB, Intel, ZTE/Sanechips   * [ZTE/Sanechips] Rel-15/16 NR specifications have **enough flexibility to support beam switching** for non-SSB channels/signals even if the lengths of CP are not enough for beam switching |

### 1st round discussion

#### Observation 4

For introduction of beam switching time gap, 16 companies expressed their views. 11 companies are proposing to support beam switching gap due to short CP length of additional SCSs which is not enough for beam switching while 3 companies want to handle it by gNB implementation. More inputs from other companies are requested on whether/how to support beam switching time gap.

Please share your views on whether/how to support beam switching time gap.

|  |  |
| --- | --- |
| **Company** | **Input** |
| LG Electronics | Discussion on beam switching time gap needs to be deferred until RAN4 send reply LS to RAN1. |
| Ericsson | Agree with LGE |
| ZTE, Sanechips | Agree with LGE |
| Sony | In our view, whether to introduce beam sweeping gap depends on RAN4’s response. If beam switching time would be relatively large, switching gap should be specified in RAN1. By now it seems too early to decide. |
| MediaTek | Agree with LGE |
| Qualcomm | We support 1-symbol gap for 480k and 960k, since the beam switch time will exceed the CP in those two cases. We are also fine to wait for RAN4 LS to confirm. |
| Intel | We understand the potential need of possible time gap especially for SCS 480 kHz/ 960 kHz. However, we think that this is possible to address relying on existing mechanisms, e.g., rate matching resources or ZP-CSI-RS. |
| Convida Wireless | We support beam switching gap for higher SCS (e.g., 960 KHz). |
| Futurewei | We support a symbol gap but agree with LGE that decision should wait for RAN4 reply. |
| Samsung | This issue can be discussed later after Ran4 send LS to Ran1. |
| DOCOMO | We are ok with waiting for LS reply from RAN4. On the other hand, according to RAN4 LS R4-2103290, at least time required for UL Tx beam switching in FR1 and FR2 is provided as transient periods by RAN4. We assume similar time duration would be required in 52.6 – 71 GHz also. CP length for 480kHz and 960kHz SCS can’t cover the required time. So we suggest to support beam switching gap at least for UL Tx beam switching case. |
| Xiaomi | Agree with LGE. |
| OPPO | Agree with LGE. |
| Moderator | Fine to defer this discussion until RAN4 LS, however, as far as I am aware of, RAN4 is currently preparing their LS to RAN1. So, I will keep this discussion for further discussion after the LS. |

#### Proposal 4

TBU

## Other parameters

### Observations and Proposals from Contributions

|  |  |
| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Ericsson, 9] | To support 480 and 960 kHz, RAN1 needs to discuss whether or not the triggering offset for an aperiodic CSI-RS resource set (aperiodicTriggeringOffset) needs to be extended above the current maximum value of 31 slots.  The CSI computation delay requirements Z3 and Z3' depend on the value indicated by the UE capability parameter beamReportTiming. All CSI computation delay requirements Z1, Z1', Z2, Z2', Z3, and Z3' should be discussed together. |

### 1st round discussion

#### Observation 5

No clear majority was observed. Please share your views on whether/how to support other timing related parameters.

|  |  |
| --- | --- |
| **Company** | **Input** |
| Qualcomm | We are fine to study other parameters. We can clarify the use case in this meeting, and start making decision in next meeting. |
| Huawei, HiSilicon | The mentioned parameters in [9] are being discussed in 8.2.5 and don’t need to be discussed here. OK in general to discuss new parameters if necessary. |
| Lenovo, Motorola Mobility | We are fine to study other parameters |
|  |  |

#### Proposal 5

TBU

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

## Multiple QCL assumptions based on timeDurationForQCL

### Observations and Proposals from Contributions

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| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | 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.  At least for delay sensitive traffics, 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.  When multi-PDSCHs are scheduled by a single DCI and the offset of a PDSCH is smaller than timeDurationForQCL, consider the solution that a scheduled PDSCH is not transmitted when its default TCI state is not associated with the PDCCH that schedules the PDSCH. |
| [Oppo, 2] | reuse the legacy principle as much as possible for QCL assumption determination: 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. |
| [Spreadtrum, 3] | 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.  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. |
| [vivo, 4] | do not support different QCL application for multiple PDSCH scheduled by a single DCI. |
| [Nokia/NSB, 5] | 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.  Support single TCI state or QCL assumption for the multi-PDSCH transmission in case of some of the PDSCHs are having lower scheduling offset than timeDurationForQCL.  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.  NW ensures single TCI state or QCL assumption across the slots for the multi-PDSCH transmission. |
| [CATT, 6] | PDSCH QCL’d with the RS in the TCI state indicated by the DCI and QCL’d with the first PDSCH scheduled by DCI may both acquire reception gain, there should be some conditions to determine the QCL assumption.  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.  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. |
| [MediaTek, 7] | 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. |
| [Futurewei, 8] | Necessity of any changes to default beam assumptions in single DCI multi-slot PDSCH scheduling should be clarified first. |
| [Ericsson, 9] | For all PDSCHs scheduled with a single DCI, when the DCI is not configured with the TCI field, the UE applies the same QCL assumption as specified in Rel-16 for the case when the scheduling offset ≥ timeDurationForQCL with the interpretation that the scheduling offset corresponds to the first scheduled PDSCH.  For multiple PDSCHs scheduled by a single DCI, if the scheduling offset for any of the PDSCHs is less than timeDurationForQCL (plus additional delay for the case of cross-carrier scheduling, if enableDefaultBeam-ForCCS is configured), the UE applies the same default QCL assumption for all scheduled PDSCHs given by the default QCL assumption for the first PDSCH. For both single and multi-TRP, the default QCL assumption for the first PDSCH is the same as that specified in Rel-16 for the case when the scheduling offset < timeDurationForQCL. |
| [Xiaomi, 10] | 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. |
| [Lenovo/MotM, 11] | 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 IDDuration/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 |
| [Intel, 12] | 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, 13] | 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. |
| [Qualcomm, 14] | Support dedicated configuration of default PDSCH beam for better optimization flexibility. gNB can dynamically update the default PDSCH beam via MAC-CE. |
| [Samsung, 15] | 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  Use indicated QCL assumption when an enough gap for beam switching is provided, otherwise keep default QCL assumption. |
| [Sony, 16] | Do NOT support multi-beam operation for single-DCI scheduled multi-PDSCH/PUSCH.  For single DCI scheduled multiple PDSCH, UE applies the same default Rx beam from the 1st PDSCH to the last PDSCH.  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. |
| [LGE, 17] | 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. |
| [Convida, 18] | 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. |
| [InterDigital, 19] | For single-TRP in NR 52.6 – 71 GHz, introduction of multi-beam based transmission for multi-PDSCH scheduling does not provide performance gain considering beam switching gaps and short slot durations for higher SCSs.  Performance gain from multi-TRP based multi-beam transmission should be carefully evaluated.  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. |
| [ZTE/Sanechips, 20] | For all PDSCHs scheduled by a single DCI with scheduling offsets less than the threshold timeDurationForQCL, same default QCL assumption(s) can be adopted.  For 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. |

### Summary of views

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| **#** | **Issue** | **Companies’ views** |
| 6.1 | Support of multiple beams based on timeDurationForQCL | **Yes (multiple beams):** Oppo, Spreadtrum, MediaTek, Futurewei, Xiaomi, Lenovo/MotM, Convida   * [Oppo]: reuse the legacy principle as much as possible for QCL assumption determination * [FW]: Necessity of any changes to default beam assumptions in single DCI multi-slot PDSCH scheduling should be clarified first.   **No (single beam):** vivo, Nokia/NSB, Ericsson, Intel, Apple, Sony, LGE, IDCC, ZTE/Sanechips   * [Ericsson]: The UE applies the same QCL assumption as specified in Rel-16 for the case when the scheduling offset ≥ timeDurationForQCL with the interpretation that the scheduling offset corresponds to the first scheduled PDSCH. * [Sony]: For single DCI scheduled multiple PDSCH, UE applies the same default Rx beam from the 1st PDSCH to the last PDSCH. * [QC]: Support dedicated configuration of default PDSCH beam and update via MAC CE   **Both:** Huawei/HiSi (based on traffic type), CATT (based on resource reservation), Samsung (if enough gap is provided) |

### 1st round discussion

#### Observation 6

No clear majority was observed on whether to support multiple beams based on timeDurationForQCL. Companies, which propose supporting multiple beams, could not find clear technical motivation to change default beam assumptions and want to reuse legacy principles as much as possible. On the other hand, companies, which propose supporting single default beam, believe that same QCL assumption are already specified in Rel-16 with the interpretation that the scheduling offset corresponds to the first scheduled PDSCH and provide better flexibility with a dedicated configuration and an update via MAC CE. In addition, some companies proposed to support both options based on traffic type, resource reservation and a time gap. More inputs from other companies are requested on the existing specification support and whether/how to support multiple beams based on timeDurationForQCL.

Please share your views on the existing specification support and whether/how to support multiple beams based on timeDurationForQCL.

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| **Company** | **Input** |
| LG Electronics | Existing specification doesn’t support default QCL assumption when multiple PDSCHs are scheduled by a single DCI but with individual TB. Thus, we need a rule at least for the case where all or some of PDSCHs scheduled by a single DCI have scheduling offset less than timeDurationForQCL. In our Tdoc, we proposed two approaches as follows:   * 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. |
| Ericsson | To align with current specification structure, the discussion should cover all of the following cases for multi-PDSCH scheduling with single DCI:   * Case 1: PDSCH scheduling offset for all PDSCHs ≥ *timeDurationForQCL*   + Case 1-1: TCI field(s) present in DCI   + Case 1-2: TCI field(s) not present in DCI * Case 2: PDSCH scheduling offset for any scheduled PDSCH < *timeDurationForQCL*   For all of these cases, we think we should strive for a simple set of rules that are straightforward extensions of Rel-15/16 covering both same and cross-carrier scheduling and both single and multi-TRP operation. This is beneficial from an implementation and specifications simplicity point of view.  For Case 1-1, our view is that the DCI should indicate a single TCI state, and that **the QCL assumption based on that TCI state is the same for all scheduled PDSCHs, and is derived in the same way as Rel-15/16** (including same/cross-carrier scheduling and single/multi-TRP for both single and multi-DCI (CORESET Pool) options).  For Case 1-2, our view is that **the default QCL assumption derived for the first (earliest) scheduled PDSCH is the same as Rel-15/16, and that the same QCL assumption is applied for all scheduled PDSCHs**.  For Case 2, our view is that **the default QCL assumption derived for the first (earliest) scheduled PDSCH is the same as Rel-15/16, and that the same QCL assumption is applied for all scheduled PDSCHs** (including same/cross-carrier scheduling and single/multi-TRP for both single and multi-DCI (CORESET Pool) options)  Adopting such simple rules is also in-line with both Rel-15 and 16 multi-slot PDSCH where the QCL assumption for the first slot applies to all slots. |
| ZTE, Sanechips | For multiple PDSCHs scheduled by a single DCI, according to the scheduling offsets between the scheduling PDCCH and each scheduled PDSCH, we think the QCL assumption(s) the UE should apply for each PDSCH for at least the following four cases should be considered.  Case A: When all of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL, and the CORESET with the lowest ID is the same for different PDSCH slots  Case B: When all of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL, and the CORESET with the lowest ID is different for different slots  Case C: When some of the scheduled PDSCHs have scheduling offset less than timeDurationForQCL while some have scheduling offset equal to or greater than timeDurationForQCL  Case D: When all of the scheduled PDSCHs have scheduling offset equal to or greater than timeDurationForQCL  We think it can be divided into the above cases for discussion, and some cases can be combined to be considered. |
| Sony | In Rel.16, the case of single-DCI scheduling multiple PDSCH (same TB) was specified with default beam applied to all scheduled PDSCH. In Rel.17 for 52.6-71GHz, it seems straight ward to apply the same rule for the case of single-DCI scheduling multiple PDSCH (different TBs). Two reasons for above suggestion. 1) multiple beam operation is not fully justified when compared with single beam operation; 2) changing Rx beam for multiple consecutive PDSCH would increase the complexity in UE RF retuning.  Therefore, we suggest to go with majority view by specifying single-beam operation. |
| MediaTek | We support to reuse Rel-15/16 default beam assumption as much as possible unless some critical issues are identified. Based on our understanding, the Rel-15/16 default beam assumption is also applied to multi-slot PDSCH(repetition), meaning that PDSCH repetitions can be received with different RX beams if they are within the timeDurationForQCL threshold. However, we are open to discuss each cases listed by Ericsson or ZTE to see whether the legacy default beam assumption is feasible or not. |
| Qualcomm | We prefer single default QCL assumption for PDSCHs within timeForQCLDuration, such that the best beam can be applied to those PDSCHs to maximize SNR without unnecessary beam switches. This issue is more pronounced for higher SCS due to more slots in timeForQCLDuration and non-negligible beam switch time. Btw, the single default QCL is not supported in R16 at least for single TRP case. We can have more spec discussion on this topic. For the progress, we suggest to first discuss whether single default QCL assumption should be supported for higher SCS. |
| vivo | Our preference is the Approach 2 in LG’s comment.  We also agree the comment that default beam behaviour in the current spec cannot apply for  individual M-PDSCHs scheduling since this is a new feature in Rel17.  Regarding alternative scheme, if different QCLs are applied for corresponding multiple PDSCHs and same MCS indicated by DCI field is shared by these PDSCHs, the statistical performance of respective PDSCH can be changed since different beam pairs may apply. In reality, the algorithm of outer loop link adaptation(OLLA) based on the feedback of HARQ-ACK to predict suitable MCS for matching wireless channels is applied to keep stable BLER (e.g. 10%) of transmission of TB, we think inconsonant statistical performance of respective PDSCH would affect the performance of OLLA and bring extra complexity for implementation of gNB. |
| CATT | As discussed in our tdoc we are ok with the following two options.   * 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. |
| Intel | We agree with cases provided by Ericsson.  When scheduling offset of PDSCH from multi-PDSCH transmission is greater than timeDuraionForQCL and tci-PresentInDCI is enabled, the UE should apply QCL assumption(s) indicated in the scheduling DCI and this indication is **single**.  Otherwise, the UE should apply the default **single** QCL assumption(s).  FFS: The default QCL assumption(s) |
| Convida Wireless | In NR Rel-16, it makes senses to apply the default TCI for all repetition PDSCHs. It is fine to reuse Rel-16 as baseline for multi-PDSCH scheduling. Since the use case of multi-PDSCH is targeting for higher SCS (e.g., 480 KHz and 960 KHz), the impaction of *timeDurationForQCL* for multi-PDSCH should consider several cases as proposed by ZTE as the starting points for discussion. |
| Futurewei | We agree with Ericsson’s classification and our preference so far is for UE to use default QCL assumption for case-1 and for case-2 use default QCL assumption derived from most recently monitored CORESET with the lowest ID. We are open to discussion but wish to highlight the following issues:  In case 1, gNB has the option of indicating a more finely optimized TCI (based on latest measurement reports) and hence mandating UE to follow either indicated TCI for all its slots or the default one in absence of indicated TCI is a natural choice.  In case 2, the gNB does not have this option. Here the default choice of mandating UE to follow QCL assumption derived from the most-recently monitored lowest ID CORESET has the advantage of reducing the number of UE beam switches and possibly gap symbols. To illustrate, we have the following figures which show that making UE follow the QCL assumption derived for its first PDSCH slot over all its remaining PDSCH slots can impose up-to twice the number of beam switches on the UE, and possibly twice the number of gap symbols. In addition, (without additional signaling enhancements) there is no benefit of the latter adopted beam in terms of being finely optimized. |
| Samsung | From our understanding multi-slot PDSCH in Rel-16 is PDSCH repetition. It is possible that the offset of some of PDSCH occasion is smaller than the timeDurationForQCL, while the others are equal or greater. The offset between PDCCH and the first PDSCH occasion among repetition is compared with timeDurationForQCL. So, if the latency of the first PDSCH occasion is smaller than timeDurationForQCL, default QCL assumption is applied for every PDSCH occasion.  We believe above Rel-16 QCL assumption can be applied for multi-PDSCH with offset less than timeDurationForQCL. For multi-PDSCH with offset equal or greater than timeDurationForQCL, TCI state in DCI or QCL assumption of CORESET used for PDCCH transmission can be applied. This approach can provide scheduling flexibility when the gNB wants to indicate beam to the UE.  Meanwhile, we believe another design aspect to consider is, if non-continuous PDSCHs can be supported, whether different QCL assumption can be applied for each burst within the non-continuous PDSCHs. |
| DOCOMO | We don’t support multiple beams for PDSCHs scheduled by one DCI based on timeDurationForQCL.  In Rel-16, it was specified that the same TCI state indicated by DCI will be applied for each PDSCH if multi-slot PDSCH is configured. There is no specification on whether to apply the same TCI state for each PDSCH if the indicated TCI state can’t be applied for the first PDSCH due to the offset between PDSCH and PDCCH is less than the threshold. However, it was clarified for MTRP case in section 5.1.5 of TS 38.214 that *“When the UE is configured by higher layer parameter repetitionScheme set to 'tdmSchemeA' or is configured with higher layer parameter repetitionNumber, the mapping of the TCI states to PDSCH transmission occasions is determined according to clause 5.1.2.1 by replacing the indicated TCI states with the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states based on the activated TCI states in the slot with the first PDSCH transmission occasion.”*.  Therefore, we think similar approach for the beam application conclusion of MTRP PDSCH repetition should be applied for discussed cases here, i.e. the same TCI state as the one for the first PDSCH should be applied to each scheduled PDSCH. |
| Xiaomi | In Rel 15/16, considering the time needed for performing PDCCH reception and applying spatial  QCL information received in DCI for PDSCH, the TCI indication used for PDCCH reception is used for PDSCH reception if the time between PDCCH and PDSCH transmissions is shorter than  timeDurationForQCL. While if the time between PDCCH and PDSCH transmissions is greater than  timeDurationForQCL, the TCI indication used for PDSCH reception, which is usually different from that for PDCCH, is indicated by DCI because of different error targets for data and control. Accordingly, multiple beams based on timeDurationForQCL should be supported.  In the discussion on feMIMO for Rel 17, the Unified TCI framework is agreed, in which the TCI indication for PDCCH and PDSCH are assumed to be the same. In unified TCI framework, multiple beams based on timeDurationForQCL should not be supported.  To sum up, we think that both options should be supported. |
| OPPO | We think it is better to reuse legacy rules as much as possible for determination of QCL assumption. Also, we notice there is discussion on enhancement of CORESET configuration in agenda 8.2.2 (PDCCH monitoring enhancements), we think this may have impacts on legacy rules and should be considered. |
| Moderator | It seems that more discussions are needed. Please continue the discussion. |
| Huawei, HiSilicon | Our understanding is that, for URLLC traffic, there is actually no workaround for multiple default beams for PDSCH scheduling offset less than timeDurationForQCL for URLLC traffic:  After a UE has received the PDCCH, especially for 480kHz/960kHz SCS whose slot duration is quite short in time, it would take multiple slots for UE to decode the content of DCI, and the TDRA information of the scheduled PDSCH is not known by the UE for those slots. Therefore, UE would only be able to use the beam of the lowest CORESET ID in the latest monitored slot to receive and buffer the signals in those slots. Only after the scheduling information of the PDSCH is decoded, UE would know which buffered time/frequency resources are carrying PDSCH to do the decoding. Therefore, when UE finds out that multiple PDSCHs are actually scheduled over those buffered slots, the PDSCH in each slot n of those buffered slots has already been received and buffered using a default beam for the slot n. Such default beam is the beam of the lowest CORESET ID in the latest monitored slot not after slot n.  For most cases (other than URLLC), it is possible to configure the lowest CORESET IDs over all the slots with offset smaller than timeDurationForQCL with the same beam. However, when slots with CORESET 0 occurs in those slots, beam switching would be inevitable, because usually CORESET 0 is targeted for transmission of multiple UEs with a wider beam, and other CORESET IDs are targeted for transmission of one UE with a narrower beam. For delay insensitive traffics, the network can schedule PDSCH after the timeDurationForQCL to make sure all PDSCHs are received with the same beam, or, the network can wait and schedule PDSCH when lowest CORESET IDs over multiple slots are configured with the same beam. For delay sensitive traffics like URLLC, however, PDSCH should be transmitted immediately. Considering the fact that PDSCHs are transmitted before the scheduling information is decoded by the UE, PDSCHs can only be transmitted using the beam of the lowest CORESET ID in the latest monitored slot, no matter whether the beams associated with the lowest CORESET IDs over those slots are the same or not. |
| Spreadtrum | We believe that R15 rules of default QCL assumption should be reused as much as possible. That is, the scheduled PDSCHs with scheduling offset less than *timeDurationForQCL* are assumed to be quasi co-located with the default beam, 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. Regarding the default beam, we are open to further study. |
| Intel | Our preference is to agree first that there should be a **single** default QCL applied for all PDSCHs from multi-PDSCH transmission with scheduling offset smaller than *timeDurationForQCL*.  The exact default QCL for multi-PDSCH could be clarified further or may be kept FFS. Our preference is the same as from Qualcomm, i.e., decouple the default QCL from QCL applied to CORESET(s). |
| Lenovo, Motorola Mobility | We prefer to have multiple QCL assumptions associated with a CORESET based on such association multiple default beams could be applied to multiple PDSCH transmissions |

#### Proposal 6

TBU

## Multiple TCI states/SRIs for multiple PDSCHs/PUSCHs

### Observations and Proposals from Contributions

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| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | In single-TRP scenario, do not indicate a separate TCI state/SRI for each scheduled PDSCH/PUSCH in Rel-17. |
| [Spreadtrum, 3] | For multi-PDSCH scheduling with a single DCI, it is not needed to indicate a separate TCI state for each scheduled PDSCH.  For multi-PUSCH scheduling with a single DCI, it is not needed to indicate a separate SRI (indication of TCI can be further discussed) for each scheduled PUSCH. |
| [vivo, 4] | do not support separate TCI state indicator for multiple PDSCH scheduled by a single DCI. |
| [Nokia/NSB, 5] | Support single SRI or a single common UL TCI state (if supported) is used for a multi-PUSCH transmission. |
| [CATT, 6] | If single DCI schedule multi-PUSCH/PDSCH is supported, multiple beam indications of PDSCH with different TCI states need to be investigated.  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. |
| [MediaTek, 7] | Support only single TCI for multi-PDSCH enhancement. |
| [Ericsson, 9] | For multiple PDSCHs scheduled with a single DCI for both same and cross-carrier scheduling, support a single TCI field in the DCI that is applicable to all scheduled PDSCHs. To support multi-TRP, the single TCI field can indicate one or two TCI states. The UE applies the QCL assumptions provided by the indicated TCI state(s) for all scheduled PDSCHs if the scheduling offset for the first PDSCH ≥ timeDurationForQCL.  As in Rel-16, for multiple PUSCHs scheduled with a single DCI support a single SRI field in the DCI that is applicable to all scheduled PUSCHs. |
| [Xiaomi, 10] | For single TRP and multi-TRP with multi-DCI, there is no need to indicate a separate TCI state for each scheduled PDSCH/PUSCH. For multi-TRP with single DCI, the TCI states for the PDSCHs/PUSCHs belonging to different TRPs should be indicated separately. |
| [Lenovo/MotM, 11] | 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 beams (multiple TCI states with QCL type-D assumption) indication via single DCI and corresponding duration of each beam within the scheduled duration: FFS the number of TCI states (beams) that can be indicated for multiple PDSCH (or PUSCH) across multiple slots by single TCI codepoint in DCI |
| [Intel, 12] | For multi-PDSCH scheduling with single DCI, separate indication of TCI state (or TCI states in case of multi-TRP) per each scheduled PDSCH or subset of scheduled PDSCH transmissions is not supported.  For multi-PUSCH scheduling with single DCI, separate indication of SRI and TCI states per each scheduled PUSCH or subset of scheduled PUSCH transmissions is not supported. |
| [Qualcomm, 14] | For single DCI scheduling multiple PDSCH/PUSCH, the indicated TCI(s)/SRI(s) can be different across PDSCHs/PUSCHs with different reliability requirements. PDSCH(s)/PUSCH(s) requiring high reliability can be transmitted via multiple TCIs/SRIs, e.g. SDM/FDM based mTRP schemes. |
| [Samsung, 15] | Support multiple TCI state/SRI indication for multi- PDSCH/PUSCH scheduled by a single DCI. |
| [Sony, 16] | Do NOT support multi-beam operation for single-DCI scheduled multi-PDSCH/PUSCH. |
| [LGE, 17] | Do not consider to indicate a separate TCI state or SRI for each scheduled PDSCH or PUSCH until it is identified as beneficial. |
| [Convida, 18] | TCI state indication methods for single DCI scheduling multi-PDSCH with M-TRP should be considered for NR from 52.6 GHz to 71 GHz. |
| [InterDigital, 19] | Support single beam indication (i.e., single TCI state/SRI indication) for multi-PDSCH/PUSCH scheduling. |
| [Docomo, 21] | For beam indication/application for multi-PDSCH/PUSCH scheduled by single DCI, For multi-PDSCH scheduling with a single DCI, no need to indicate a separate TCI state for each scheduled PDSCH.For multi-PUSCH scheduling with a single DCI, no need to indicate separate SRI(s) for each scheduled PUSCH.For multi-PDSCH scheduling, TCI states for PDSCHs scheduled by a single DCI follows the TCI state applied for the first PDSCH. |

### Summary of views

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| **#** | **Issue** | **Companies’ views** |
| 7.1 | Introduce multiple TCI states for multi-PDSCHs and multiple SRIs for multi-PUSCHs | **Yes:** CATT, Lenovo/MotM, Samsung, Convida   * [Samsung]: The multiple PDSCHs or PUSCHs with different QCL assumptions can provide diversity gain. For another example, it is beneficial to support   **No:** Huawei/HiSi, Spreadtrum, vivo, Nokia/NSB, MediaTek, Ericsson, Xiaomi, Intel, Sony, IDCC, Docomo   * [vivo]: In case of single TRP, we do not think the beam pair will change during the multi-PDSCH transmission. In case of multiple TRP, different TCI state indicator for multi-PDSCH with different HARQ ID has been supported by introducing the parameter of CORESET pool index which is scheduled by multi-DCI.   **Both:** Qualcomm (based on priority) |

### 1st round discussion

#### Observation 7

Majority of companies (13 companies) do not want to introduce multiple TCI states for multi-PDSCHs and multiple SRIs for multi-PUSCHs. The majority of companies believe that beam pair will not change during the multi-PDSCH transmission in case of single TRP. In addition, for multi-TRPs, different TCI states can be indicated by utilizing multiple DCIs with different CORESET pool ID. On the other hand, 5 companies believe that different QCL assumption can provide diversity gain for multiple PDSCHs/PUSCHs.

#### Proposal 7

For NR operation in 52.6-71GHz, different QCL assumption for multiple PDSCHs/PUSCHs scheduled by a single DCI is not supported.

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| **Company** | **Input** |
| LG Electronics | In general, we are supported of Proposal 7. In addition, it would be better to clarify that it is for single TRP and FFS on m-TRP case. |
| Ericsson | Isn't it more accurate to write the proposal as follows:  For multiple PDSCHs/PUSCHs scheduled by a single DCI, support indication of only a single TCI state/SRI in DCI |
| ZTE, Sanechips | The proposal is somewhat ambiguous and literally covers all the cases discussed in section 3.1. So we think Ericsson’s description is more accurate. We support indication of only a single TCI state/SRI in DCI. |
| Sony | Support the FL proposal in principle.  We just would like to state that different (up to 2) QCL assumption for each of multiple PDSCH/PUSCH could come from multi-TRP. For this case, it should be supported. The different QCL assumptions from PDSCH/PUSCH to PDSCH/PUSCH is not what we desire. |
| MediaTek | Either the FL proposal with further clarification or Ericsson’s proposal is ok to us. |
| Qualcomm | Basically fine with Proposal 7. But it should also be extended to mTRP case, where the same 2 TCIs/spatial relations are applied to all TBs. So we suggest to add “(s)” for the case of mTRP, i.e the same set of beams is applied to all TBs.  For NR operation in 52.6-71GHz, different QCL assumption(s)/spatial relation(s) for multiple PDSCHs/PUSCHs scheduled by a single DCI is not supported. |
| vivo | Support FL’s proposal.  We also think the proposal is for M-TRP case. Since M-PDSCH/PUSCH scheduling from two TRPs has been supported in Rel16 by configuring two different CORESET pool index. We do not support revisiting S-DCI based M-PUSCH scheduling from M-TRP in Rel17 which has been abandoned in Rel16. |
| CATT | We still think this is beneficial and can be supported. |
| Intel | We prefer the text suggested by Ericsson.  Different QCL assumptions for multi-PDSCH/PUSCH transmission is possible (e.g., default QCL and QCL from TCI state signalled in scheduling DCI). However, only single TCI state/SRI indication in the scheduling DCI should be supported. |
| Convida Wireless | We are fine with Ericsson’s revised proposal (only a single TCI/SRI state in DCI). |
| Futurewei | We prefer Ericsson’s re-write and support single TCI/SRI indication in the DCI. |
| Samsung | We agree with LGE that it would be better to clarify the proposal.  Also, our view is that different QCL assumption for multiple PDSCH/PUSCH scheduled by a single DCI is supported for single-TRP. Since NR operation in 52.6-71 GHz may experience higher blockage than FR2, a transmission beam can be blocked frequently. So, if single TCI state is applied for multi-PDSCH and the TCI state is blocked, the UE may fail to receive every PDSCHs. In order to provide robustness and diversity gain we support multiple TCI state for multi-PDSCH/PUSCH. |
| DOCOMO | Support the proposal and agree to clarify it is for single TRP case.  For single TRP case, we think there is no strong motivation to separately indicate beam for each PDSCH/PUSCH unless for high UE mobility case. However, multi-PDSCH/PUSCH may not target for such high mobility cases due to frequent channel condition changes even if high UE mobility may be supported in 52.6 – 71 GHz. Moreover, DCI overhead will be largely increased if beam indication field needs to be reserved for the maximum number of scheduled PDSCHs/PUSCHs. |
| Xiaomi | We do not agree with proposal 7. Well, for single TRP and multi-TRPs with multiple DCIs, this proposal is OK for us. However, as discussed in our contribution, for multi-TRPs with single DCI, multiple PDSCHs/PUSCHs scheduled by a single DCI may belong to different TRPs as shown below, which needs further study. In this case, the beams for the PDSCHs/PUSCHs of different TRPs need to be indicated separately.    Therefore, we suggest the proposal can be modified as follows:  For the QCL assumption for multiple PDSCHs/PUSCHs scheduled by a single DCI in NR from 52.6 to 71GHz   * Different QCL assumption is not supported for single TRP and multi-TRPs with multiple DCIs * FFS: Different QCL assumption is support for multi-TRPs with single DCI if the multiple PDSCHs/PUSCHs scheduled by a single DCI is allowed to belong to different TRPs |
| OPPO | We share similar view as Samsung and Xiaomi. |
| Moderator | Please check Proposal 7a updated based on the comments from LGE and Ericsson. |

#### Proposal 7a

For multiple PDSCHs/PUSCHs scheduled by a single DCI, at least for single TRP, support indication of only a single TCI state/SRI in DCI

FFS: number of TCI states/SRIs in a single DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP

|  |  |
| --- | --- |
| **Company** | **Input** |
| LG Electronics | Support Proposal 7a |
| DOCOMO | Support Proposal 7a.  But we think similar principle can be applied for multi-TRP case, i.e. only a single TCI state/SRI for PDSCHs/PUSCHs scheduled by a single DCI for the same TRP. |
| Huawei, HiSilicon | We can support Proposal 7a without FFS. We are not sure the FFS part should be handled in this AI when parallel related discussions are going on in FeMIMO. |
| Spreadtrum | We are fine with moderator’s updated proposal. |
| MediaTek | We share the same view with Huawei that the FFS point might be better to be discussed in FeMIMO agenda item. |
| Qualcomm | The mTRP extension should be supported. We don’t see the reason why such extension is not allowed. Our understanding is that the mulit-TB scheme is to improve spectrum efficiency. Allowing mTRP can further improve this. |
| Intel | We support Proposal 7a |
| Futurewei | We are fine with the proposal. |
| Lenovo, Motorola Mobility | We strongly oppose this proposal. We think for such high FR beyond 52.6, beams are typically very narrow and also there is high probability of beam blockage. Therefore, multiple TCI states should be supported regardless of single TRP or multiple TRP case |
| Ericsson | In several comments above, thank-you to companies for pointing out that our original proposal seemed to preclude multi-TRP. That was not our intention; our intention was to say that there is only one TCI/SRI field, but that that single field can of course indicate two TCI states in the case of multi-TRP.  We think the following minor correction should be adopted for consistency with the main bullet.  For multiple PDSCHs/PUSCHs scheduled by a single DCI, at least for single TRP, support indication of only a single TCI state/SRI in DCI  FFS: ~~number of~~ indication of more than one TCI state~~s~~/SRI~~s~~ in a single DCI scheduling multiple PDSCHs/PUSCHs for multi-TRP |

## Other beam indication related issues

### Observations and Proposals from Contributions

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| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [CATT, 6] | In initial access, the beam adaptation for Msg3 and Msg4 transmission can be adapted based on the beam measurement report from UE. |
| [Ericsson, 9] | Do not support scheduling of multiple PDSCHs with a single DCI where the TB(s) corresponding to one or more of the PDSCHs is(are) mapped over multiple slots by legacy TB repetition (semi-statically configured by pdsch-AggregationFactor or dynamically indicated by repetitionNumber in TDRA table). Beam indication procedures for such a combination are not needed.  As in Rel-16, do not support scheduling of multiple PUSCHs with a single DCI where one or more of the PUSCHs is(are) mapped over multiple slots by legacy TB repetition (Type A or B repetition). Beam indication procedures for such a combination are not needed. |
| [Lenovo/MotM, 11]: | 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. |
| [Qualcomm, 14] | Support UE report of recommended SSB in Msg3/A in initial access.  Support dynamic beam update of periodic channel/RS.  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. |

### Summary of views

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 8.1 | Support of multi-PDSCHs/PUSCHs with TB repetition and beam indication mechanism | **No:** Ericsson |
| 8.2 | QCL assumption update for configured grant PUSCH transmissions | **Yes:** Lenovo/MotM |
| 8.3 | Beam report in Msg3/A | **Yes:** CATT, Qualcomm |
| 8.4 | Dynamic beam update of periodic channel/RS | **Yes:** Qualcomm |
| 8.5 | Dynamic update of TCI state configuration | **Yes:** Qualcomm |

### 1st round discussion

#### Observation 8

No clear majority was observed. Please continue discussion.

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| --- | --- |
| **Company** | **Input** |
| Qualcomm | We prefer to at least study the beam realignment in initial access, e.g. beam report in Msg3/A or later messages. Otherwise, beam realignment may only start after the RRC connection setup. |
| Lenovo, Motorola Mobility | We prefer to study the following:   * Beam update of periodic RS (may or may not be dynamically updated) * Configured grant PUSCH beam update based on latest beam for DG PUSCH |
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#### Proposal 8

TBU

# **Beam Management for Shared Spectrum Operation**

## Observations and Proposals from Contributions

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| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Huawei/HiSi, 1] | 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. |
| [Oppo, 2] | holding the discussion on AP-CSI-RS for BFR/BFD until the LBT procedure has been made clear in agenda item 8.2.6. |
| [Nokia/NSB, 5] | 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.  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  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).   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. |
| [CATT, 6] | When UE can not 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.  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. |
| [MediaTek, 7] | 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.  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. |
| [Futurewei, 8] | Utilize aperiodic CSI-RS transmission to address impact of LBT failure on periodic RS transmissions intended to support beam failure recovery.  Consider support for low latency beam (QCL-TypeD) switch of periodic RS transmissions after sustained LBT failure.  In No-LBT deployments consider specification of channel vacation policies accounting for disparity among co-existing devices. |
| [Ericsson, 9] | 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). |
| [Xiaomi, 10] | Beam measurement based on periodic CSI-RS can be still supported in NR for 52.6 to 71 GHz.  Aperiodic CSI reports can be triggered to patch a non-transmitted periodic CSI-RS. |
| [Lenovo/MotM, 11] | 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 encounteredDynamic 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 |
| [Intel, 12] | 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. |
| [Samsung, 14] | Support multi-slot aperiodic CSI-RS/SRS scheduled by a single DCI for beam management in 60 GHz unlicensed band.  Further investigate the issue on the uncertainty of RS transmission due to LBT for 60 GHz unlicensed band. |
| [Sony, 16] | Depending on periodic BFD RS and CBD RS, UE would not be able to evaluate DL quality at the periodic occasion(s), due to no indicated COT.  Support aperiodic CSI-RS for beam failure detection (BFD) and candidate beam determination (CBD) at least for unlicensed band  Study and specify if needed single DCI scheduled multiple aperiodic CSI-RS and/or aperiodic SRS across multiple slots. |
| [LGE, 17] | 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 failureHow to enhance beam failure procedure considering not transmitted BFD-RS due to LBT failure |
| [InterDigital, 19] | Absence of periodic/semi-persistent RSs may impact on performance of fine time/frequency tracking, beam failure recovery and beam/CSI reporting.  Introduce an enhanced mechanism to patch non-transmitted periodic/semi-persistent RSs due to LBT failures  Support RS transmission based on candidate RSs when LBT fails for periodic/semi-persistent RSs.  Support RS pre-emption based on gNB indication to achieve accurate fine time/frequency tracking, beam failure recovery and beam/CSI. |
| [ZTE/Sanechips, 20] | Study and evaluate the impact of LBT and the limitation of COT length on the procedure of beam failure detection. |
| [Docomo, 21] | Beam failure detection/recovery procedure in NR 52.6-71GHz can consider following potential enhancements, whether to introduce aperiodic RS monitoring for beam failure detection |

## Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 9.1 | Whether to enhance RS transmissions to deal with LBT failure | **Yes:** Huawei/HiSi, Nokia/NSB, MediaTek, Futurewei, Lenovo/MotM, Samsung, Sony, LGE, IDCC, ZTE/Sanechips, Docomo   * [Nokia/NSB]: 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) * [IDCC]: Support RS pre-emption based on gNB indication to achieve accurate fine time/frequency tracking, beam failure recovery and beam/CSI.   **No:** CATT, Ericsson, Xiaomi, Intel   * [Ericsson]: 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 |

## 1st round discussion

### Observation 9

It is observed that majority of companies (15 companies) want to introduce enhancement on RS transmission to deal with LBT failure. The supporting companies believe that patching failed RSs or transmitting multi-slot RSs for CSI-RS (e.g., for tracking and beam failure recovery) and SRS are beneficial. On the other hand, 4 companies believe that failed RSs can be handled by gNB implementation and no special handling is needed.

### Proposal 9

For NR operation in 52.6-71GHz, support enhancement on RS transmission to deal with LBT failure.

|  |  |
| --- | --- |
| **Company** | **Input** |
| LG Electronics | It would be better to describe more details on which kind of enhancements is need for RS transmission to deal with LBT failure. |
| Ericsson | This proposal is too vague. If any enhancement is to be agreed, it needs to be discussed exactly what enhancement and for exactly what purpose. |
| ZTE, Sanechips | Some modifications on FL proposal are suggested to make:  For NR operation in 52.6-71GHz, study whether/how to ~~support~~ enhance~~ment~~ on RS transmission to deal with LBT failure. |
| Sony | Support in general.  But like LGE and Ericsson said, we may need to be more specific on how to enhance RS transmission, e.g. using AP-CSI-RS as beam failure detection RS, BFD-RS. |
| MediaTek | We would like to clarify that our position is to study the feasibility of the proposed enhancement for handling LBT failure. Therefore, before agreeing on FL proposal, we suggest to list the proposal enhancements and discuss further. |
| Qualcomm | We do not support RS enhancement for LBT failure. The impact of LBT failure should be negligible for highly directional communications. Such enhancement was discussed but not adopted in NR-U, where the LBT failure is even more severe. |
| vivo | We are open to study RS enhancement. But this proposal is to general to be agreeable. |
| CATT | We are open to study alternative measurement. |
| Intel | The necessity of such enhancements is still questionable for us. Because of that, we don’t support the suggestion from moderator. |
| Convida Wireless | We are open for the discussion. For example, CSI-RS/SR enhancement with or without LBT failure for NR from 52.6-71 GHz. This topic could be deferred for discussion in this meeting. |
| Futurewei | We are supportive of RS enhancement and agree with need for clarifying RS enhancement details. |
| Samsung | We agree with LGE and Ericsson that more details for the proposal would be better. |
| DOCOMO | Support the proposal in principle and agree it better to discuss enhancement scopes. |
| Xiaomi | We think that more specific enhancements on RS transmission to deal with LBT failure should be discussed. For instance, aperiodic CSI reports can be triggered to patch a non-transmitted periodic CSI-RS. |
| ITRI | We support RS enhancement for LBT failure |
| OPPO | We are open to discuss this issue. |
| Moderator | I failed to observe a clear majority view. Please provide your inputs on following questions.  Q1. Whether to support enhancement of RS transmission?  Q2. If agree to support the enhancement, whether to restrict the enhancement to a specific use case (e.g., BFR or TRS)?  For example, current beam failure monitoring/detection and new beam is based on periodic CSI-RS. If we agree to enhance periodic CSI-RS, then beam failure recovery can naturally support the enhancement.  Q3. If agree to restrict the enhancement to a specific feature, preferred use case? |
| Huawei, HiSilicon | Q1: Yes. Support enhancement of RS transmission to deal with LBT failure.  Q2: At least for BFR use case. We are open to discuss other issues that are of interest to other companies.  Q3: Not sure the difference of Q2 and Q3. |
| Spreadtrum | Q1: we are not supportive of enhancement of RS transmission. In R16 NR-U the RLM-RS is not enhanced to deal with LBT failure. The same situation applies to R17 RS enhancement, especially the directional LBT reduces the probability of LBT failure. |
| MediaTek | Q1: No (Without seeing a justification of the impact of LBT failure in this frequency band and without seeing some strong candidates of solutions, we prefer not to support any enhancement at this point) |
| Qualcomm | Q1: Not support. Not an critical issue even for NR-U. |
| Intel | Q1: We tend not to support enhancements of RS transmission in order to address LBT failures. Our view is that LBT failures can be handled by existing framework based on periodic RS transmission. |
| Lenovo, Motorola Mobility | Q1. Whether to support enhancement of RS transmission?  **A1: Yes, support enhancement of periodic RS transmission due to LBT failure**  Q2. If agree to support the enhancement, whether to restrict the enhancement to a specific use case (e.g., BFR or TRS)?  For example, current beam failure monitoring/detection and new beam is based on periodic CSI-RS. If we agree to enhance periodic CSI-RS, then beam failure recovery can naturally support the enhancement.  **A2: Yes, it could be restricted for periodic CSI-RS transmission. Our intention is not to initiate BFR procedure due to LBT failure. Rather provide mechanism to change the beam after it encounters a certain number of LBT failures. In this case, basically the CSI-RS resource QCL assumption is updated. We have discussed more detailed mechanism in our contribution**  Q3. If agree to restrict the enhancement to a specific feature, preferred use case?  **A3: Same as A2** |

# **Beam Failure Recovery**

## Observations and Proposals from Contributions

Please note that observations and proposals on enhancements of monitoring/candidate RSs are captured in section 4.1.

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| **Company** | **Observations and Proposals from Contributions** |
| [Ericsson, 9] | 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. |
| [Qualcomm, 14] | Support partial BFR for single TRP. |
| [InterDigital, 19] | Due to the narrower beamwidth in 52.6 – 71 GHz, UE may not successfully recover dynamic blockage based on the existing BFR operation.  Enhanced BFR operation to provide better reliability and efficiency should be considered for higher frequencies.  Support partial BFR to achieve better reliability in 52.6 – 71 GHz. |

## Summary of views

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| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 10.1 | Timing enhancement | **Yes:** Ericsson (28 symbol window for decoding PDCCH needs to be revisited.  **No:** |
| 10.2 | Support of partial BFR | **Yes:** Qualcomm, IDCC  **No:** |

## 1st round discussion

### Observation 10

No clear majority was observed. Companies are requested to share their views on whether and how to enhance beam failure recovery.

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| **Company** | **Input** |
| LG Electronics | It should be clarified that the motivation of those suggestions are to cope with LBT failure in unlicensed band. Otherwise, they seem to be out of scope. Furthermore, partial BFR can be discussed in Rel-17 FeMIMO WI. |
| Ericsson | Agree with LGE |
| ZTE, Sanechips | De-prioritize the discussion on above optimization issues in this meeting. |
| Intel | The proposals from companies on BFR enhancements are quite general (e.g., support of partial BFR). We think that such kind of BFR enhancements should be treated within Rel-17 feMIMO WI. |
| Convida Wireless | BFR/BFD related issues can be deferred for this meeting. |
| Futurewei | We agree to defer this discussion to the next meeting |
| Samsung | It’s better to list concrete proposals and the targeted issue to resolve. In our understanding, only new BFR issues originated from new SCS or LBT need to be handled in this agenda. |
| DOCOMO | We are supportive of BFD/BFR enhancement and we think following potential enhancements for new SCS and LBT can be considered:   * whether to increase the number of candidate beams included in set * whether to introduce a new time gap (larger than 28 symbols) to apply new beam configuration after receiving BFR response from gNB * whether to introduce aperiodic RS monitoring for beam failure detection |
| Xiaomi | Agree with LGE |
| Huawei, HiSilicon | We are OK to continue discussing possible BFR enhancement in the next meeting. |
| Spreadtrum | Agree with LGE. |
| Lenovo, Motorola Mobility | We are supportive of enhanced beam failure recovery procedure |

### Proposal 10

TBU

# **Supporting Efficient Beam Management**

## Observations and Proposals from Contributions

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| --- | --- |
| **Company** | **Observations and Proposals from Contributions** |
| [Xiaomi, 10] | 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.  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.  It is beneficial to support group-based triggering of aperiodic CSI reports for UEs configured with same periodic CSI-RS resources used for beam measurement.  There is a limitation on the number of periodic CSI-RS resource used for beam measurement in Rel15/16.  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. |
| [Qualcomm, 14] | Investigate sub-band based beam report. |
| [Convida, 18] | 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. |
| [InterDigital, 19] | In order to compensate increased pathloss and maintain cell coverages in 52.6 – 71 GHz, utilization of narrower beam than FR2 is expected.  If the existing beam management mechanism is applied with the same number of beams, more frequent RRC reconfiguration and MAC CE signaling are expected.  Increased signaling overheads and latencies will lead to inefficient system operation and corresponding performance degradation of NR in 52.6 – 71 GHz.  Essential enhancements should be considered for beam management in 52.6 – 71 GHz e.g., increased maximum number of CSI-RS resources and configured/activated TCI states. |
| [Docomo, 21] | 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. |

## 1st round discussion

### Summary of views

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 11.1 | RS enhancement to deal with increased number of beams | **Yes:** Xiaomi, IDCC, Docomo  **No:** |
| 11.2 | CSI reporting enhancement | **Yes:** Xiaomi, Qualcomm, Docomo  **No:** |

### Observation 11

No clear majority was observed. Companies are requested to share their views on whether/how to support efficient beam management.

|  |  |
| --- | --- |
| **Company** | **Input** |
| LG Electronics | It should be clarified that the motivation of those suggestions are to cope with LBT failure in unlicensed band. Otherwise, they seem to be out of scope. |
| Ericsson | Agree with LGE |
| ZTE, Sanechips | De-prioritize the discussion on above optimization issues in this meeting. |
| Intel | We agree with the view from ZTE |
| Futurewei | We agree with ZTE and Intel on deferring this discussion to the next meeting. |
| Samsung | We are open to discuss on the impact from supporting more beams, which is a reasonable outcome from supporting higher SCS. The corresponding increase of CSI reporting seems within the scope of the discussion, and other CSI reporting enhancement may need further justification.  In particular, to deal with increase number of beams, we proposed to support multi-slot aperiodic CSI-RS/SRS scheduled by a single DCI for beam management in 60 GHz unlicensed band. |
| Xiaomi | From our understanding, efficiency of beam management refers to the overhead associated with beam management operations and latency for reporting and indicating new beams. We want to make it clear that our proposals listed above in this section are actually about the potential enhancements on beam measurement to deal with the LBT. And they are not about supporting efficient beam management. The efficiency of beam management needs further study and duplication of work between work items in Rel-17 should be avoided. |
| Huawei, HiSilicon | We are OK to defer this discussion. Also, some of the proposals discuss an increased number of beams to increase the coverage. In our view, coverage enhancement using an increased number of beams is not in the scope of this release. Please note that we have not increased the number of SSB beams to enhance the coverage in this release. |
| Lenovo, Motorola Mobility | We are ok to further discuss this. |

### Proposal 11

TBU

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6. R1-2102624, “Beam management for new SCSs for up to 71GHz operation,” CATT
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19. R1-2103451, “Discussions on beam management for new SCSs,” InterDigital, Inc.
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