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

**e-Meeting, January 25th – February 5th, 2021**

**Agenda Item: 8.2.4**

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

**Title: Discussion summary of [104-e-NR-52-71GHz-04] #2**

**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#104-e.

# **Summary of Views on a Basis of Beam-based Operation**

The following are observations/proposals related to a basis for beam management for NR in 52.6 – 71 GHz.

## Observations and Proposals from Contributions

### Support Rel-15/16 as a basis

###### From [ZTE/Sanechips, 3]:

* + - Rel-15/16 NR specifications have enough flexibility to support beam switching for non-SSB channels/signals with new SCS 480 kHz and 960 kHz.
    - Beam management in Rel-15/16 NR could be used as the basis for specifying NR operation above 52.6 GHz.

###### From [Huawei/HiSi, 5]:

* + - At least the beam management procedure defined in Rel-15/16 can be the baseline for operation in 52.6GHz to 71GHz.

###### From [vivo, 8]:

* + - Support beam management of R15/16 as a basis in the discussion of B52.6G and the specification of beam management in Rel-17 MIMO WI should support NR operation from 52.6-71GHz.

###### From [Intel, 9]:

* + - Support both Rel-15/16 and Rel-17 beam management frameworks for NR extension up to 71 GHz.

###### From [InterDigital, 10]:

* + - In Rel-17 beam management, various aspects are still FFS or not discussed yet.
    - Given the situation, other sub-agendas in FeMIMO topic (e.g., beam management for multi-TRP) are assuming Rel-15/16 beam management as a baseline.
    - Rel-15/16 beam management should be considered as beam management scheme for the extension of NR for 52.6 – 71 GHz.

###### From [Samsung, 14]:

* + - Prefer using Rel-17 beam management as basis for NR 52.6 to 71 GHz.
      * Can support Rel-15/16 beam management in addition if time allows.

###### From [NTT Docomo, 19]:

* + - Rel-15/R16 beam management should be considered as the baseline for discussing potential enhancement on beam-based operation in 52.6 – 71 GHz.

### Support Rel-17 as a basis

###### From [Futurewei, 1]:

* + - Beam management of NR\_ext\_to\_71GHz should use R17 based beam management as a basis.

###### From [Intel, 9]:

* + - Support both Rel-15/16 and Rel-17 beam management frameworks for NR extension up to 71 GHz.

###### From [Xiaomi, 13]:

* + - Beam management in Rel17 should be used as a basis in NR-U-60-LBT.

###### From [Samsung, 14]:

* + - Prefer using Rel-17 beam management as basis for NR 52.6 to 71 GHz.
      * Can support Rel-15/16 beam management in addition if time allows.

###### From [Ericsson, 15]:

* + - Beam management features available up to Rel-16 as well as enhancements introduced in the Rel-17 feMIMO WI can be used for the 52.6 – 71 GHz band if beneficial for a particular deployment.

## 1st round discussion

Based on the above observations/proposals, summary of views on a basis of beam-based operation is provided in the table below.

### Summary of views on a basis of beam-based operation

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 1 | Basis of beam-based operation for NR 52.6 – 71GHz | Rel-15/16   * ZTE/Sanechips, Huawei/HiSilicon, vivo, Intel, IDCC, Samsung (if time allows), NTT Docomo   Rel-17   * Futurewei, Intel, Xiaomi, Samsung |

### Observation

It is observed that majority of companies are supporting Rel-15/16 while four companies are supporting Rel-17. As MIMO delegates are currently developing Rel-17 features, from the moderator point of view, it would be better to assume Rel-15/16 as a basis and discuss further on applying Rel-17 features for NR in 52.6-71GHz. Companies supporting Rel-17 are requested to share the plans on how to support Rel-17 features for NR in 52.6-71GHz.

### Proposal 1

For NR operation in 52.6-71 GHz, support following beam management methods:

* Rel-15/16 beam management.
* Working assumption: Rel-17 beam management.

### Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Futurewei | Not support Proposal 1. As discussed in our contribution R1-2100052, due to the higher SCS and narrower beamwidth in 52.6-71 GHz, beam management enhancements similar to those developed in Rel-17 are required if using Rel-15/16 as basis, repeating/overlapping the work currently undergoing in FeMIMO WID.  [Mod] Based on Futurewei’s view, updated proposal is provided to support Rel-15/16 as an agreement and Rel-17 as a working assumption. In my view, for Rel-17, it would be better to have a working assumption as it is not finalized yet. Please share your view on the updated proposal. |
| Qualcomm | We are fine to have R15/16 as baseline. |
| vivo | Support proposal 1. |
| Ericsson | In our paper we made the below observation supporting Rel-17 beam management. In our view, toward the end of the work item, we can check what features and progress has been made in the Rel-17 feMIMO WI on beam management enhancements. On a feature-by-feature basis, we can discuss whether or not a feature requires any updates to timing aspects to make it functional in the 52.6 – 71 GHz band. If simple updates are needed, then those can be considered. If major enhancements are needed to make the feature work, then that could be deferred to a later release.   1. Beam management features available up to Rel-16 as well as enhancements introduced in the Rel-17 feMIMO WI can be used for the 52.6 – 71 GHz band if beneficial for a particular deployment.   [Mod] I updated your observation in the summary. Also, updated proposal is provided to support Rel-15/16 as an agreement and Rel-17 as a working assumption. As you commented, we can confirm Rel-17 features after having enough details. If there’s a feature which requires major enhancements, then we can confirm Rel-17 beam management except the feature. Please check and let me know if you have a suggestion. |
| DCM | Support the proposal. |
| Samsung | To clarify our position first, we support Rel-17 BM as baseline as the primary task, and Rel-15/16 BM is a secondary task. So we are ok with either Rel-17 alone or both as a baseline, but not Rel-15/16 alone.  It would be a big misfortunate if Rel-17 BM is not supported for 52.6 to 71 GHz. As mentioned in our tdoc, Rel-17 beam management is mainly targeting FR2 enhancement, so it’s more straightforward to use it as baseline here. Also, Rel-17 FeMIMO has started for several meetings, and all the framework for Rel-17 beam management is done, so we didn’t see issue with applying it to 52.6 to 71 GHz (actually we didn’t expect much work to be done for supporting Rel-17 BM). If there are issues identified already that Rel-17 BM is not applicable for 52.6 to 71 GHz, we’d like to know the details.  [Mod] While Rel-17 FeMIMO started for several meetings, I don’t think Rel-17 FeMIMO has enough details now. For example, exact definition of beam application time and supported DCI formats are not defined yet. However, I also understand that Rel-17 beam management can be more efficient than Rel-17. In that sense, I propose a comprised proposal to agree Rel-15/16 as an agreement and Rel-17 as a working assumption. Please check and let me know your view. |
| LG Electronics | Support Proposal 1. |
| Huawei, HiSilicon | We believe that although Rel-15/16 GHz can be used as a basis for beam management, the developments in this WI should not be at odds or conflicting with Rel-17 MIMO beam management enhancements. Rel-17 MIMO beam management enhancements should also be applicable to 52.6-71 GHz with no or minimal adjustments (that may be done during maintenance phase if necessary).  Having said that, we think we should first focus on the aspects that are unlikely to be affected in Rel-17 MIMO beam management enhancements to avoid overlap. For instance, enhancements related to the shared spectrum can be the main focus at the earlier stages of this WI. In later stages of Rel-17 when the Rel-17 MIMO beam management enhancements are more or less mature, the scope of discussion of beam management in 52.6-71 GHz may be broaden in which case the agreements made in Rel-17 MIMO beam management will be taken into account. |
| ZTE, Sanechips | We support moderator’s Proposal 1 and views in Observation 1. As Rel-17 FeMIMO is still under discussion, there are many issues that have not yet come to conclusions. Rel-15/16 versions are frozen and relatively stable. If some common issues on BM need to be discussed, coordination can be made across two WI groups. |
| Moderator | Please check the updated proposal 1 based on the comments from Futurewei, Ericsson and Samsung. |
| Intel | The work on beam management for NR extension up to 71 GHz should start relying on Rel-15/16 beam management framework with addition of Rel-17 beam management enhancements later on. So, eventually, both Rel-15/16 and Rel-17 beam management should be supported in NR extension up to 71 GHz. However, general enhancements to beam management should be kept within feMIMO WI and focus should be enabling beam management functionalities in 60GHz band. |
| Apple | Honestly speaking, the implication of Proposal 1 is not very clear for us and should be clarified. It is our understanding that generally any Rel-17 WI is built on top of previous Release features i.e., Rel-16 beam management operation. At the end of Rel-17 WI, it is expected to have UE features discussion to cope with cross-WI features interaction. Focusing on this case, the application of Rel-17 FeMIMO to above 52.6GHz or unlicensed operation should be still allowed and if possible, supported by a Rel-17 UEs.  In summary, it is necessary to clarify what the Proposal 1 implies, i.e., UE capable of >52.6GHz is assumed to be incapable of Rel-17 FeMIMO if we agree Proposal 1? Or something else?  [Mod] I am not sure why proposal 1 is not very clear. Current beam management was designed assuming FR1 and/or FR2 operation. If we don’t define related parameters/values e.g., timeDurationForQCL for Rel-15/16, Rel-15/16 beam management will not work. For Rel-17 FeMIMO, the proposal 1 proposes to support Rel-17 FeMIMO, however, some Rel-17 FeMIMO feature may not be applicable to NR in 52.6-71GHz as Rel-17 FeMIMO is considering FR2 not a frequency band in 52.6-71GHz. If we agree proposal 1, we can start discussion what would be needed to support Rel-17 beam management as well as Rel-15/16 beam management. Please note that this aspect is already captured in the WID as follows:   * + Specify timing associated with beam-based operation to new SCS (i.e., 480kHz and/or 960kHz), study, and specify if needed, potential enhancement for shared spectrum operation     - Study which beam management will be used as a basis: R15/16 or R17 in RAN #91-e |
| Lenovo, Motorola Mobility | We are against Proposal 1. Beam management enhancement needs to be considered for dealing with high SCS and the potential narrow beams. Rel-17 MIMO enhancements should be applicable in this WI.  Furthermore, specific enhancements for high SCS should be dealt here.  [Mod] The proposal does not say that Rel-17 MIMO enhancements are not applicable. Actually, it is saying that Rel-17 is supported. If you have a better wording, please suggest. |
| Nokia/NSB | We don’t think this should be discussed. We don’t need to preclude any operation specifically for this band. But, on parallel work for Rel-17, it is natural to consider Rel-15/16 as a starting point.  [Mod] This proposal is not to preclude any operation, but to support both. Please note that this scope is captured in the WID as follows:   * + Specify timing associated with beam-based operation to new SCS (i.e., 480kHz and/or 960kHz), study, and specify if needed, potential enhancement for shared spectrum operation     - Study which beam management will be used as a basis: R15/16 or R17 in RAN #91-e |
| Convida Wireless | We are fine with using Rel15/16 as baseline for beam management for NR from 52.6 GHz to 71 GHz. Agreed Rel-17 FeMIMO WID for beam management can be considered and supported as well. |
| Xiaomi | We are fine with proposal 1. After a further study on the beam management in 52.6-71 GHz, we need to discuss whether the beam management features in Rel17 can be applied in the beam management procedure in 52.6-71 GHz via checking these features one by one. As discussed in our paper, the enhancements on multi-beam operation in Rel17 are proposed to facilitate the efficiency of DL/UL beam management. The efficiency here refers to the latency and overhead associated with beam management, like the latency for beam indication. These enhancements are good references for us to discuss the beam management in NR from 52.6 GHz to 71 GHz especially when narrower beamwidth is used to compensate for larger propagation loss due to high atmospheric absorption. |
| Charter | We support starting with Rel-15/16 and subsequently considering and adapting potential enhancements to be developed in Rel-17; focusing first on enablers for beam management in 52.6-71 GHz, e.g. timings associated with beam-based operation (cf. next section), will benefit the development. |

### Conclusions from GTW Session

Agreement:

Rel-15/16 and any Rel-17 beam management enhancements can be considered for 52.6-71 GHz. Whether particular features should be excluded for 52.6-71 GHz can be further discussed.

* Note: As per usual procedure, duplication of work between work items in Rel-17 should be avoided

# **Summary of Views on Supported Timings Associated with Beam-based Operation**

The following are observations/proposals related to timings associated with beam-based operation for NR in 52.6 – 71 GHz.

## Observations and Proposals from Contributions

### General observations/proposals on supported timings associated with beam-based operation

###### From [Futurewei, 1]:

* + - NR\_ext\_to\_71GHz supports introducing new values for multi-beam operation related timing parameters associated with new SCS (i.e., 480kHz and/or 960kHz).

### Support of Rel-15/16 timings

###### From [ZTE/Sanechips, 3]:

* + - The time for applying a new beam after receiving PDCCH with BFR response for the new supported SCS 480 kHz / 960 kHz may need to be re-considered.
    - The value of shortest periodicity for the physical layer to inform whether beam failure occurs should be re-considered for NR operation above 52.6 GHz.
    - For determining PDSCH QCL assumption, the value of timeDurationForQCL for the new supported SCS 480 kHz / 960 kHz needs to be re-considered.
    - The value of beamReportTiming, beamSwitchTiming and beamSwitchTiming-r16 for the new supported SCS 480/960 kHz needs to be re-considered.

###### From [OPPO, 4]:

* + - 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, 98, 154 |
| 960kHz | 56, 98, 154 |

* + - Adopt the following time duration QCL for 120kHz, 480kHz and 960kHz.

|  |  |
| --- | --- |
| SCS | Time duration QCL (symbol) |
| 120kHz | 14,28,48 |
| 480kHz | 56, 98, 154 |
| 960kHz | 56, 98, 154 |

* + - Adopt the following beam report timing for 120kHz, 480kHz and 960kHz.

|  |  |
| --- | --- |
| SCS | Beam report timing (symbol) |
| 120kHz | 14,28,56 |
| 480kHz | 56, 98, 154 |
| 960kHz | 98, 154, 224 |

###### From [Huawei/HiSi, 5]:

* + - 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.

###### From [Nokia/NSB, 6]:

* + - Define parameter values (UE capabilities) for the timeDurationForQCL for 480 and 960 kHz.
    - Define parameter values (UE capabilities) for the beamSwitchTiming for the A-CSI-RS triggering for 480 kHz and 960 kHz SCS.
    - Assuming the same absolute times for timeDurationForQCL with 480 and 960 kHz SCSs the corresponding values would be:
      * 56 symbols (4 slots) or 112 symbols (8 slots) with 480 kHz SCS
      * 112 symbols (8 slots) or 224 symbols (16 slots) with 960 kHz SCS

###### From [CATT, 7]:

* + - The beam management framework should be reused for NR operation in 52.6-71 GHz.
    - The number of symbols for the timeDurationForQCL parameter for 480 kHz and 960 kHz SCS should increase in proportion comparing to that of reference lower SCS, e.g., 120 kHz SCS.

###### From [Intel, 9]:

* + - Support both Rel-15/16 and Rel-17 beam management frameworks for NR extension up to 71 GHz.
    - Identify all Rel-15/16 beam management parameters related to timing and extend their definitions with SCS values of 480 kHz and 960 kHz.
    - Modify relevant RRC parameters to account UE capabilities for beam management with updated values corresponding to SCS 480 kHz and 960 kHz.

###### From [IDCC, 10]:

* + - Rel-17 beam management may provide better signaling efficiency and shorter latency not only for FR2 but also for 52.6 – 71GHz, if applicable.
    - If applicable, timing and timeline associated with Rel-17 beam management should be defined for 52.6 – 71 GHz as well as timing and timeline associated with Rel-15/16 beam management.
  + From [Sony, 11]:
    - RAN1 evaluates and extends (if necessary) the UE capability of timeDurationForQCL, beamSwitchTiming and beamReportTiming from SCS 120kHz at FR2 to SCS 480kHz and SCS 960kHz for 52.6GHz to 71GHz frequency band.

###### From [LGE, 12]:

* + - Define new values for timeDurationForQCL corresponding to 480 kHz and 960 kHz SCSs.
    - Define new values for beamSwitchTiming corresponding to 480 kHz and 960 kHz SCSs and define corresponding UE behaviour to determine QCL assumption for triggered aperiodic CSI-RS.
    - Define new values for additional beam switching time delay d corresponding to 120 kHz and 480 kHz SCSs of triggering DCI.

###### From [Xiaomi, 13]:

* + - UE needs to provide the beamSwitchTiming values corresponding to new SCSs.
    - For these new SCSs, UE should report the corresponding beamReportTiming values to the network.
    - The timeDurationForQCL values should be update to support these new SCSs introduced in NR-U-60-LBT.

###### From [Ericsson, 15]:

* + - To support 480 and 960 kHz SCS, RAN1 needs to discuss appropriate values for the UE capabilities on PDCCH-to-PDSCH timing (timeDurationForQCL) and PDCCH-to-CSI-RS timing (beamSwitchTiming) that determine the spatial QCL assumption to be used for reception of PDSCH and ap-CSI-RS, respectively.
    - 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.
    - Beam management features available up to Rel-16 as well as enhancements introduced in the Rel-17 feMIMO WI can be used for the 52.6 – 71 GHz band if beneficial for a particular deployment.
    - 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).

###### From [Qualcomm, 18]:

* + - UE capability on beam switch related scheduling offset should be specified per new SCS, including timeDurationForQCL and beamSwitchTiming.
    - UE capability on beam switch execution latency should be introduced per new SCS for required time gap between previous and new beams.
    - UE capability on beam switch count should be specified per new SCS.
    - UE capability on minimum beam dwelling time should be introduced per new SCS.

### Support of Rel-17 timings

###### From [Huawei/HiSi, 5]:

* + - Support for the beam management enhancements specified in Rel-17 MIMO WI should be considered in 52.6 GHz to 71 GHz at later stages of Rel-17 WI when these enhancements are stable.

###### From [Intel, 9]:

* + - Support both Rel-15/16 and Rel-17 beam management frameworks for NR extension up to 71 GHz.
    - Identify all Rel-15/16 beam management parameters related to timing and extend their definitions with SCS values of 480 kHz and 960 kHz.
    - Modify relevant RRC parameters to account UE capabilities for beam management with updated values corresponding to SCS 480 kHz and 960 kHz.

###### From [IDCC, 10]:

* + - Rel-17 beam management may provide better signaling efficiency and shorter latency not only for FR2 but also for 52.6 – 71GHz, if applicable.
    - If applicable, timing and timeline associated with Rel-17 beam management should be defined for 52.6 – 71 GHz as well as timing and timeline associated with Rel-15/16 beam management.

### Introduction of beam switching time between signals/channels

###### From [Lenovo/MotM, 2]:

* + - For supporting NR from 52.6 GHz to 71 GHz in Rel. 17, if higher subcarrier spacings (numerologies) are adopted for initial access, 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 before beam switching.

###### From [ZTE/Sanechips, 3]:

* + - The following options can be considered for supporting beam switching for SSB with SCS 480 kHz and 960 kHz.
      * Option 1: In a half-frame, any two candidate SSBs are discontinuous in the time domain
        + Option 1-1: SSB pattern with SCS 480/960 kHz can adopt the existing pattern of Case A and Case C in one or two slots defined in Rel-15 NR
        + Option 1-2: SSB pattern with SCS 480/960 kHz should be re-designed to reserve at least one symbol between any two candidate SSBs, e.g. only defining one candidate SSB per slot
      * Option 2: Multiple adjacent candidate SSBs are defined to have a same SSB index or QCL assumption

###### From [CATT, 7]:

* + - Beam switching gap would be sufficient with gNB implementation solution.

###### From [vivo, 8]:

* + - Further study the spec impacts of beam switching time on beam measurement and data transmission for B52.6 operation.
    - Timeline of a-CSI RS triggering should be further enhanced for 52.6GHz.

###### From [LGE, 12]:

* + - At least for 960 kHz SCS, discuss how to handle beam switching delay between DL/UL signals/channels.

###### From [Samsung, 14]:

* + - Reserve one symbol for beam switching gap when using 480 kHz and 960 kHz SCSs.

###### From [Qualcomm, 18]:

* + - Clarify beam switch definition/scenario. Time gap should be inserted to where beam switch happens with duration satisfying UE capability.

## 1st round discussion

Based on the above observations/proposals, summary of views on supported timings associated with beam-based operation is provided in the table below.

### Summary of views on supported timings associated with beam-based operation for new SCSs

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.1 | Supported release timings associated with beam-based operation | Rel-15/16   * timeDurationForQCL   + ZTE/Sanechip, Oppo, Huawei/HiSi, Nokia/NSB, CATT, Sony, LGE, Xiaomi, Ericsson (in ns), Qualcomm, IDCC * beamSwitchTiming and/or beamSwitchTiming-r16   + ZTE/Sanechip, Oppo, Huawei/HiSi, Nokia/NSB, Sony, LGE, Xiaomi, Ericsson (in ns), Qualcomm, IDCC * beamReportTiming   + ZTE/Sanechip, Oppo, Huawei/HiSi, Sony, Xiaomi, Ericsson (in ns), IDCC * Additional beam switching time delay d   + Vivo, LGE * Extension of aperiodicTriggering offset   + Ericsson   Rel-17   * Futurewei, Samsung |
| 2.2 | New timing definition for 52.6 – 71GHz | Beam switching time between signals/channels   * **Yes:** Lenovo/MotM, ZTE/Sanechip, vivo, LGE, Samsung, NTT DOCOMO * **No:** CATT |

### Observation

It is observed that majority of companies are supporting defining timeDurationForQCL, beamSwitchTiming and beamSwitchTiming-r16 and beamReportTiming. Other timing parameters such as additional beam switching time delay d and aperiodicTriggering offset were proposed by some companies. Companies are encouraged to share views on other parameters. In addition, companies supporting Rel-17 timing parameters are requested to share the plans on how to define Rel-17 features for NR in 52.6-71GHz.

### Proposal 2

For NR operation in 52.6-71GHz with new SCSs,

* Introduce new UE capability parameter values for following Rel-15/16 timing parameters in addition to the UE capability parameters for existing SCSs:
  + timeDurationForQCL
  + beamSwitchTiming and beamSwitchTiming-r16
  + beamReportTiming
  + FFS: Whether to introduce new values or use scaled values of 120 kHz
  + FFS: other beam-related Rel-15/16 UE capability parameters (e.g., additional beam switching time delay d for beamSwitchTiming and beamSwitchTiming-r16)
* Introduce new UE capability parameter values for following Rel-15/16 beam switch count parameter in addition to the UE capability parameters for existing SCSs:
  + maxNumberRxTxBeamSwitchDL
  + FFS: Clarify the beam switch definition (e.g. whether beam switch is counted across SSBs, CSI-RS resources with Repetition ON, DL/UL channel switch, etc.)
* Study whether/how to introduce a beam switching gap between signals/channels
  + FFS: condition to apply
* FFS: Rel-17 beam-related timing parameters
* Companies are encouraged to provide preferred values on timeDurationForQCL, beamSwitchTiming, maxNumberRxTxBeamSwitchDL, beamSwitchTiming-r16 and beamReportTiming in RAN1#104bis-e

### Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Futurewei | There are currently discussions in FeMIMO WID on beam management related timing issues, which is highly related to this topic. Discussion/coordination with the FeMIMO WID are needed.  [Mod] As you mentioned, Rel-17 timing parameters are not defined yet. So, in my view, we can start from Rel-15/16 parameters and discuss Rel-17 parameters after having enough details. |
| Qualcomm | The following R15/16 UE capability on beam switch count should be applied to higher band, since the beam switch could happen more frequently for higher SCS. Another related issue is the definition of beam switch, which is not well clarified in R15. This is more critical for higher band, since gNB and UE may have significant misalignment on where the time gap for beam switch should be reserved. The corresponding new bullet is added to Proposal 2 as below.  ***maxNumberRxTxBeamSwitchDL***  Defines the number of Tx and Rx beam changes UE can perform on this band within a slot. UE shall report one value per each subcarrier spacing supported by the UE. In this release, the number of Tx and Rx beam changes for scs-15kHz and scs-30kHz are not included.  **Proposal 2**:  For NR operation in 52.6-71GHz with new SCSs,   * Following Rel-15/16 timing parameters are defined:   + timeDurationForQCL   + beamSwitchTiming and beamSwitchTiming-r16   + beamReportTiming   + FFS: other Rel-15/16 timing parameters   + FFS: order of the timing parameters (e.g., 10s of ns or 10s of symbols) * Introduce a beam switching time between signals/channels * Following Rel-15/16 beam switch count parameter is defined:   + maxNumberRxTxBeamSwitchDL   + FFS: Clarify the beam switch definition (e.g. whether beam switch is counted across SSBs, CSI-RS resources with Repetition ON, DL/UL channel switch, etc.) * Companies are encouraged to provide preferred values on timeDurationForQCL, beamSwitchTiming, maxNumberRxTxBeamSwitchDL, beamSwitchTiming-r16 and beamReportTiming in RAN1#104bis-e   [Mod] The proposal seems reasonable and I updated Moderator’s proposal accordingly. |
| vivo | Our understanding of this proposal is to reuse existing Rel-15/16 timing parameter definitions with possible new values for 5.26 to 71 GHz with new SCSs. If that’s the case, suggest rewording “defined” for clarity.  [Mod] Your understanding is correct. The updated proposal based on Ericsson’s comment is provided. Please check the updated proposal. |
| Ericsson | We are generally fine with the proposal; however, we have questions on the following two bullets:   * + FFS: order of the timing parameters (e.g., 10s of ns or 10s of symbols) * Introduce a beam switching time between signals/channels   On the 2nd bullet, is the intention that a new capability parameter is introduced on the beam switch time between signals/channels in addition to the existing parameters timeDurationForQCL, beamSwitchTiming, beamReportTiming? If this is the intention, then we are supportive; we think it can be useful for the UE to inform the network of a need for such a switching gap or the gap duration, for example, between CSI-RS/SRS resources in a resource set. In this case the switching gap would be on the order of 10s of ns, not 10s of symbols as for the existing capability parameters timeDurationForQCL, beamSwitchTiming, beamReportTiming.  [Mod] The intention of proposal 2 is to introduce new capability parameters as you mentioned. The updated proposal based on your comment is provided.  Or is the intention that a beam switching gap can be configured between signals/channels? For CSI-RS/SRS, at least, a gap can already be configured between resources.  We think it is needed to clearly define what is meant, i.e., a configured gap vs. a capability parameter.  [Mod] My intention was to propose a general specification support and to discuss such details later as many companies raised the issue rather than proposing detailed specification support. Based on your comment, I updated the bullet as FFS and we can discuss details after having enough details from other companies.  We are supportive of revisiting the value of the beam switch count parameter mentioned by Qualcomm.  [Mod] Updated the parameter. |
| DCM | We are fine with the proposal. This is to deal with shortened time duration of a symbol, which is specific to 52.6 – 71 GHz WI. We should discuss on the points above here. |
| Samsung | We are ok with the proposal. Rel-17 beam related parameters could also be discussed when they are available from FeMIMO session.  [Mod] This is to introduce identified beam-related parameters not to preclude other parameters. Based on your comment, I updated the proposal with the updated FFS bullet on Rel-17 parameters. |
| LG Electronics | * For “FFS: other Rel-15/16 timing parameters”, we suggest to add an example of Additional beam switching time delay *d* i.e., FFS: other Rel-15/16 timing parameters (e.g., Additional beam switching time delay d for beamSwitchTiming and beamSwitchTiming-r16). Since beam switching time delay *d* is the additional offset value of beamSwitchTiming and beamSwitchTiming-r16 when ap-CSI-RS is triggered by different numerology PDCCH as specified in TS 38.214, they are tightly relevant.   [Mod] Updated with the example.   * Before RAN1 introduce beam switching gap, the first step would be RAN4 to confirm whether beam switching gap required to gNB and UE can be larger than normal CP of 480 or 960 kHz. So, we may need to send an LS to RAN4 for confirmation.   [Mod] As we already have a defined beam switching time from RAN4, I am not sure that we need to send an LS to RAN4. However, if other companies propose the same, I can reflect the proposal. Let’s see comments from other companies.   * For “beamSwitchTiming and beamSwitchTiming-r16”, it is necessary to consider related UE behavior of QCL assumption for triggered ap-CSI-RS together. This is because currently different UE behavior to determine reference RS for ap-CSI-RS is defined based on the beam switching threshold (e.g., 48 symbols for 224/336 beam switch timing). Therefore, if possible, we prefer to put “FFS: How to define corresponding UE behavior to determine QCL assumption for triggered aperiodic CSI-RS” under the bullet for “beamSwitchTiming and beamSwitchTiming-r16”.   [Mod] I am not sure that what would be newly defined UE behavior to determine QCL assumption as we already have clear UE behavior. More detailed elaboration is requested. |
| Huawei, HiSilicon | OK with introduction of timeDurationForQCL, beamSwitchTiming, and beamReportTiming. The scaled version of the values for 120 kHz can be used as a starting point (4 times for 480 kHz SCS and 8 times for 960 kHz).   * As for beam switching time between signals/channels in 480/960 kHz SCS, it may not be necessary to have a configurable parameter for this. Instead, it may be specified that UE is not expected to receive downlink data or control channel or reference signals with different QCL-D properties on adjacent symbols within a slot.   [Mod] Updated the bullet as FFS |
| ZTE, Sanechips | For the 2nd bullet on introducing a beam switching time, we think it can be solved by configuration implementation, and/or a transmission mechanism (e.g. for continuous SSBs).   * For timeDurationForQCL, beamSwitchTiming, beamSwitchTiming-r16 and beamReportTiming with SCS 480/960kHz, the preferred values can be obtained by scaling of correponding values for SCS 120kHz.   [Mod] Added a FFS bullet on introducing new values or using scaled values |
| Moderator | Please check the updated proposal 2 based on the comments from Qualcomm, vivo, Ericsson, Samsung, LGE, Huawei and ZTE. |
| Intel | The definition of the following beam management parameters from Rel-15/16 framework should be extended with values for SCS 480 kHz and 960 kHz:   * TimeDurationForQCL * beamSwitchTiming * beamReportTiming   Another beam management parameter which should be considered is maxNumberRxTxBeamSwitchDL.  Although we understand motivation to introduce a beam switching time between signals/channels, we think that some additional clarification on this parameter is needed especially regarding signal/channel types. As a starting point, an introduction of SSB beam switching time could be considered. |
| Apple | Our understanding on the proposal is to ‘the value for the following Rel-15/16 timing parameters are defined’, which is valid discussion point for us.  [Mod] Updated the bullet based on your comment. |
| Lenovo, Motorola Mobility | Agree with the proposal. Also agree with Futurewei that coordination with the ongoing discussion for FeMIMO WI is needed.  For beam switching time between signals/channels, our view is that it is mainly required when multiple PDSCH or multiple PUSCH are scheduled over multiple slots. In this case, multiple beams should be indicated and the duration for each beam should be indicated. For example, if 8 slots are indicated for PDSCH and 4 beams are indicated by TCI state. Then duration for each of the beams should be indicated as well. Such as if beam duration for each beam is 2 slots, then the beam switching is applied after every two slots (PDSCH transmissions).  [Mod] Multiple beam aspects are discussed in proposal 3. |
| Nokia/NSB | We are fine with the original proposal in general, but beam switching time between signals/channels are ambiguous. So, we cannot agree on introducing the unclear parameter. So, propose as     * Study whether/how to Introduce ~~a~~beam switching time between signals/channels * FFS: condition to apply.   [Mod] Reflected your comment. |
| Xiaomi | OK with proposal 2. |
| Moderator | Please check the updated proposal based on the comments from Apple and Nokia. |

### Conclusions from GTW Session

Agreement:

* For NR operation in 52.6-71GHz with new SCSs, new parameter values for at least the following timing parameters are needed:
* timeDurationForQCL
* beamSwitchTiming
* beamReportTiming
* Companies are encouraged to provide preferred values on timeDurationForQCL, beamSwitchTiming and beamReportTiming

## 2nd round discussion

### Observation

There are remaining issues on maxNumberRxTxBeamSwitchDL and introduction of a beam switching gap between signals/channels from GTW session. Companies further inputs are requested. Please provide your inputs in the table below.

### Proposal

For NR operation in 52.6-71GHz with new SCSs,

* Further study new parameter values for at least the following parameters:
  + maxNumberRxTxBeamSwitchDL
  + Additional beam switching time delay d
* Study whether/how to introduce a beam switching gap between signals/channels (e.g., introduction of beam switching time between SSBs)
  + FFS: condition to apply including potential UE capability definition
* FFS: beam-related timing parameters for Rel-17 beam management

### 2nd round inputs

|  |  |
| --- | --- |
| **Company** | **Input** |
| Huawei, HiSilicon | The first and the last bullets of proposal 2 are already reflected in agreement and need to be removed.  [Mod] You comment was on the previous version before updating the agreement. Please check the new proposal in 3.3.2 based on the draft proposal from GTW session.  We are having problem understanding the FFS for the second bullet (“ FFS: Clarify the beam switch definition….”). This is a UE capability introduced in Rel-15 for FR2. We think that this WI can only discuss the parameter values of an existing capability for the new SCSs. If the definition of this capability is unclear, it should be clarified in MIMO WI. If 71Ex WI thinks that this parameter may have a specific meaning/application in 480/960 kHz SCS that is applicable for lower SCSs, then it would probably be better to try to define a new capability altogether that is only applicable to 480/960 kHz SCS. Therefore, we cannot agree with this bullet in this form.  [Mod] FFS bullet is proposed by Qualcomm. I removed the FFS bullet based on your comment. However, I don’t think this WI can only discuss the parameter values of an existing capability for the new SCSs as WID does not have the word “existing” in the WID. For example, we can introduce UE capability parameters for a time gap with high SCSs if it is agreeable.  The third bullet seems to be applicable only to 480/960 kHz SCS and this needs to be clarified.  [Mod] The first sentence for whole bullets is saying that this for new SCSs, so there is no need to clarify.  The fourth bullet is quite vague. Are we talking about new beam related timing parameters for Rel-17 or new parameter values for Rel15/Rel16 beam related timing parameters?  [Mod] New beam related timing parameters for Rel-17 beam management. I updated the wording based on your comment. If it is still vague, let me know.  Currently, the only part of Proposal 2 that we can agree with (other than the parts that are already agreed in the last GTW) is the following:  **Proposal:**   * Study whether/how to introduce a beam switching time gap between signals/channels for 480/960 kHz SCS |
| LG Electronics | We share the similar view with Huawei, and fail to see the additional value in addition to what we made in the last GTW session. Based on the last GTW session, any beam-related timing parameters including Rel-17 parameters are all FFS. If we start to list-up now, we suggest to add Additional beam switching time delay d for beamSwitchTiming and beamSwitchTiming-r16, as we commented earlier.  [Mod] I removed the FFS bullet based on your comment. |
| Charter | We understand and generally agree with the reworded, clearer Proposal 2, in line with comments from Ericsson, Qualcomm, Nokia, Intel.  We suggest a further, minor rewording of the 2nd and 3rd *outer* bullets in Proposal 2, which we feel may further lessen any remaining ambiguity:   * Extend the following Rel-15/16 UE capability beam switch count parameter to new SCSs by expanding its value range beyond existing SCSs.   + *maxNumberRxTxBeamSwitchDL*   + FFS: … * Study whether/how to *provision* a beam switching gap between signals/channels   While the former reworded bullet is more or less self-explanatory, the latter is based on our understanding that, *if ultimately provisioned*, such gap can be either ‘configured’ via an already–existing (accommodating) mechanism or custom–specified via a *newly* introduced ‘capability parameter.’  In essence, the solution for a ‘beam switching gap between signals/channels’ may very well be a mix of gap configuration and new capability parameter(s): the reworded bullet leaves room for both.  Finally, we agree with Intel’s comment on the merit of elaborating on the gap’s dependence on signal/channel *types*; and on testing the concept on SSB, as a starting point.  [Mod] Updated based on your comments. |
| Sony | We share the same with Huawei on “FFS: Clarify the beam switch definition”. We failed to see the difference between FR2 beam switch definition and 52.6-71GHz beam switch definition. If needed, this kind of definition should already been given, but if not needed, then we don’t have to define it particularly for 52.6-71GHz.  We are okay with other parts.  [Mod] I removed the FFS bullet based on your comment. |
| DCM | For the updated proposal in 3.3.2,   * For the first bullet, we think similar wording as in the agreement as in 3.2.5 is better for consistency. And we think Huawei’s comment on “FFS: Clarify the beam switch definition….” is valid. * We are fine with the remaining parts, although agreeing on such FFSs may not be so meaningful in WI phase.   [Mod] Updated based on your comments. |
| ZTE, Sanechips | For NR above 52.6GHz, we understand that the intention of this agenda is to discuss whether the existing capability parameter value can meet the requirement of beam switch for newly introduced SCSs. From this point of view, we think here the definition of beam switch is clear, no need to extend considering additional other cases, such as the 2nd FFS. For the 2nd FFS, it seems to be more suitable to be discussed or determined in Rel-17 MIMO. Thus, we disagree the 2nd FFS to be discussed herein.  Besides, for the last FFS, it may need to be clarified further which parameters would be considered as Rel-17 beam-related timing parameters.  [Mod] I removed the 2nd FFS bullet based on your comment. For the last FFS, as FeMIMO discussion is still ongoing and there’s no clearly defined parameters yet, it is premature to clarify which parameters would be considered. |
| Intel | We support the updated proposal.  Our understanding is that maxNumberRxTxBeamSwitchDL is the total number of all Tx and Rx beam switches at the UE. This is certainly a beam management parameter which value depends on SCS, and it’s RAN1’s task to keep the same values for new SCS 480 kHz and 960 kHz or add new ones. |

# **Summary of Views on Supporting Multiple Beams for Multiple PDSCHs**

The following are observations/proposals related to support multiple beams for multiple PDSCHs for NR in 52.6 – 71 GHz.

## Observations and Proposals from Contributions

### Support multiple beams for multiple PDSCHs

###### From [Lenovo/MotM, 2]:

* + - 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 applicability/duration of each beam within the scheduled duration.

###### From [Huawei/HiSi, 5]:

* + - For 480 kHz and 960 kHz SCS, UE is not expected to receive downlink data or control channel or reference signals with different QCL-D properties on adjacent symbols within a slot.

###### From [CATT, 7]:

* + - If single DCI scheduled multi-PUSCH/PDSCH is supported, multiple beam indications of PDSCH with different TCI states need to be investigated.

###### From [Samsung, 14]:

* + - Further investigate the overhead for supporting multi-beam indication for multi-PDSCH/PUSCH scheduled by a single DCI.

###### From [Convida, 17]:

* + - TCI state indication methods for single DCI scheduling multiple PDSCHs should be studied for NR from 52.6 GHz to 71 GHz.

### Support single beam for multiple PDSCHs

###### From [Nokia/NSB, 6]:

* + - 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.
    - Consider single QCL assumption for the multi-PDSCH transmission in case of some of the PDSCHs are having lower scheduling offset than timeDurationForQCL.

###### From [Qualcomm, 18]:

* + - Support default PDSCH beam invariant across slots to facilitate cross-slot combining for new SCSs.

## 1st round discussion

Based on the above observations/proposals, summary of views on supporting multiple beams for multiple PDSCHs is provided in the table below.

### Summary of views on supporting multiple beams for multiple PDSCHs

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3 | Whether to support multiple TCI states for multiple PDSCHs | Number of beams for multiple PDSCHs   * **Single beam:** Nokia/NSB, Qualcomm, Futurewei, Ericsson, ZTE/Sanechips, Xiaomi * **Multiple beams:** Lenovo/MotM, CATT, Samsung, Convida, Huawei/HiSi |

### Observation

No clear majority was observed. Companies are requested to share their views on whether and how to support multiple beams for multiple PDSCHs.

### Proposal 3

Further study whether/how to support multiple beams for multiple PDSCHs/PUSCHs scheduled by a single DCI at least for following scenarios:

* DCI scheduling PDSCH(s)/PUSCH(s) over multiple slots indicates a single beam. But some of scheduled PDSCH(s)/PUSCH(s) are within timeForQCLDuration, while others are outside of timeForQCLDuration
* DCI scheduling PDSCH(s)/PUSCH(s) over multiple slots indicates multiple beams.

### Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Futurewei | Considering the required UE’s capability to switch receiving beam within short time duration, it seems it is not necessary to support multiple beams for multiple PDSCHs scheduled by a single DCI.  [Mod] Updated the position in Table 5. |
| Qualcomm | We are fine for Proposal 3 as start point.  To clarify, our proposal of single beam is for PDSCHs with scheduling offset less than timeForQCLDuration, i.e. fixed default PDSCH beam.  This provides the option to use an optimized default beam to maximize PDSCH SNR across slots when PDSCHs are scheduled with scheduling offset less than timeForQCLDuration for lower latency.  [Mod] Please correct the position in Table 5 if my understanding is wrong. |
| vivo | OK to FFS. |
| Ericsson | We are not supportive of defining multiple beam indications when multi-PDSCH is scheduled for several reasons:   * The time duration is short as mentioned by Futurewei, hence we do not see that it is likely that beams should change * It becomes unnecessarily complicated to manage if some of the PDSCHs are scheduled with offset less than the threshold timeDurationForQCL and some scheduled with offset greater than the threshold * Multiple indications come at a cost in DCI overhead to indicate multiple TCI states, with questionable benefit   [Mod] Reflected the position in Table 5. |
| DCM | We think possible use case of multiple beams for multiple PDSCHs scheduled by a single DCI needs to be clarified first. Moreover, if multiple beams for multiple PDSCHs is supported, it seems similar motivation applies for multiple PUSCHs. |
| Samsung | If multi-TRP is supported at gNB, it’s natural to consider multiple beams for multi-PDSCHs. |
| LG Electronics | It seems that the scope is to some extent overlapped with other agenda item, i.e., scheduling and HARQ in 8.2.5. However, it’s OK to discuss how to deal with the case where offset between a DCI and some or all of multiple PDSCHs scheduled by the DCI can be less than timeForQCLDuration. |
| Huawei, HiSilicon | Our view in the t-doc was not accurately reflected in the FL summary. Our discussion in the t-doc was actually for single DCI scheduling single PDSCH, and we do not see the need for specifying a gap symbol to account for beam switch latency in that case.  We do believe however there should be a gap symbol between two adjacent symbols with different QCL-D properties in a slot for 480/960 kHz SCS. Such a gap symbol can be supported between two different PDSCHs in a multi-PDSCH scheme. So, technically, it is possible to have multiple beams for multiple PDSCHs scheduled by a single DCI.  Therefore, whether or not to support multiple beams for multiple PDSCH can be discussed further and we do see some potential benefits in it. For instance, if DCI schedules multiple PDSCH#0,…,N and the time offset between DCI and PDSCH#0 is smaller than timeDurationForQCL, the PDSCH#0 is assumed to be QCLEd with the lowest CORESET ID. This may not be a good practice to make the same QCL assumption for PDSCH#N if its time offset from DCI is larger than timeDurationForQCL and the TCI field is present in DCI since the CORESET#0 is usually a wide beam while TCI indicated in DCI is a narrow beam.  [Mod] Reflected the position in Table 5. |
| ZTE, Sanechips | We support single beam for multiple PDSCHs scheduled by a single DCI since multiple beams will increase the overhead of switching, UE complexity, and standardization complexity. Thus, it would be better for UE to maintain the assumptions defined in TS 38.214, original text is copied below:  *“When the UE is configured with a multi-slot PDSCH, the indicated TCI state should be based on the activated TCI states in the first slot with the scheduled PDSCH, and UE shall expect the activated TCI states are the same across the slots with the scheduled PDSCH.”*  [Mod] Reflected the position in Table 5. |
| Moderator | Further inputs are requested. Inputs are requested from companies which didn’t share views. |
| Intel | Agree with moderator’s proposal |
| Apple | We are supportive to enable this for multiple PDSCH scheduling on >52.6GHz. On the other hand, this feature is part of Rel-17 FeMIMO. We need to first identify the issues that are not covered by FeMIMO WI to avoid duplicated efforts.  [Mod] Clearly, this issue is not covered by FeMIMO WI as FeMIMO do not consider multi PDSCH scheduling. |
| Lenovo, Motorola Mobility | Depends on the scheduling duration of multi PDSCH scheduled by a single DCI, we see that multi TCI states indication is required given UE mobility and the potential narrow beams. For example, if 8 slots are indicated for PDSCH and 4 TCI states are indicated by TCI codepoint. Then duration for each of the TCI state should be indicated as well. Such as if duration for each TCI state is 2 slots, then the TCI (beam) switching is applied after every two slots (PDSCH transmissions). |
| Nokia/NSB | Fine to study. But, other than M-TRP TDM repetition schemes, the use case for switching beams in a short duration is not clear.  Also, PUSCH beams should be discussed together (which is proposed in 8.2.5 multi-PUSCH scheduling)    **Proposal 3**:  Further study supporting multiple beams for multiple PDSCHs/PUSCHs scheduled by a single DCI.    [Mod] Updated |
| Convida Wireless | We support moderator’s proposal. Multiple beams for multiple PDSCHs scheduled by a single DCI can be further studied for licensed and unlicensed bands. |
| Xiaomi | Support single beam multi-PDSCH scheduling. For multi-beam multi-PDSCH scheduling, currently we see no obvious benefit. We provided our view in Table 5. |
| Moderator | Please check the updated proposal based on Nokia’s comment. |
| Huawei, HiSilicon | Support updated proposal in v019 |
| LG Electronics | Based on companies inputs, there can be two scenarios:   * 1) DCI scheduling PDSCH(s)/PUSCH(s) over multiple slots indicates a single beam. But some of scheduled PDSCH(s)/PUSCH(s) are within timeForQCLDuration, while others are outside of timeForQCLDuration * 2) DCI scheduling PDSCH(s)/PUSCH(s) over multiple slots indicates multiple beams.   The argument point for scenario 1) is that it can be handled by gNB scheduling or may require additional specification impact such that UE can assume different beams depending on within timeForQCLDuration, or outside of timeForQCLDuration.  The argument point for scenario 2) is whether it is beneficial or not. If gNB scheduling 8 slots for 960 kHz SCS, how can gNB predict UE’s beam status change during 8 slots? Or, how can UE’s beam status be instantaneously changed during 8 slots?  At least these argument points should be discussed first from our view.  [Mod] Updated the scenarios in the proposal. |
| Charter | Agree with Moderator’s updated Proposal 3 as a further study. |
| Sony | Given the fact that the pros and cons of multi-beam for multi-PDSCH have not been fully discussed, we support FL’s proposal to keep it as FFS at the moment. |
| DCM | We think it’s better to clarify possible use case and benefit of multiple beams for multiple PDSCHs/PUSCHs scheduled by a single DCI. So we proposed to update the proposal as:  Proposal 3:  Further study whether/how to support ~~supporting~~ multiple beams for multiple PDSCHs/PUSCHs scheduled by a single DCI.  [Mod] Updated the proposal. |
| Intel | As there are different views, we propose to reformulate the text of Proposal 3 and unify it with Proposal 5 as follows:  Further study whether or not the support of multiple beams for multiple PDSCHs/PUSCHs scheduled by a single DCI is needed. |

# **Summary of Views on Supporting Beam Management for Unlicensed Band**

The following are observations/proposals related to supporting beam management for NR in 52.6 – 71 GHz.

## Observations and Proposals from Contributions

### Support enhancements on periodic RS transmissions to deal with LBT failure

###### From [Lenovo/MotM, 2]:

* + - For NR operation in unlicensed bands between 52.6 GHz and 71 GHz, then following potential enhancements related to periodic transmissions of RS such as P-TRS should be specified to deal with LBT failure:
      * Termination of periodic RS transmission on beams where consecutive LBT failures are encountered
      * Dynamic switching of the QCL assumption (beams) for periodic RS transmission where consecutive LBT failures are encountered

###### From [Nokia/NSB, 6]:

* + - 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.
    - Consider solutions to provide robustness for TRS transmission due to LBT failures, for instance:
      * A beam specific (SSB specific) aperiodic TRS transmission that could be triggered for one or multiple UEs at a time to “patch” non-transmitted P-TRS using certain beam (certain SSB as QCL-TypeD source)
      * Multiple transmission opportunities for the P-TRS within a time period
    - 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).

###### From [LGE, 12]:

* + - The following aspects can be considered to enhance beam management operation when channel access scheme is used for unlicensed spectrum.
      * How to provide more opportunities of CSI-RS or SRS transmission considering LBT failure
      * How to enhance beam failure procedure considering not transmitted BFD-RS due to LBT failure

###### From [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.

###### From [Apple, 16]:

* + - Support triggering multiple A-CSI-RS transmissions on a same CC by a single DCI and a single beam measurement report to reduce the UL signalling overhead.

###### From [Convida, 17]:

* + - Introduction of TRS/CSI-RS in idle/inactive state UE in Rel-17 should be studied for beam management during initial access for NR from 52.6 GHz to 71 GHz.
    - 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.

### Handling by gNB implementation without specification impact

###### From [CATT, 7]:

* + - When UE detects the miss-transmission of periodic CSI-RS 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 opportunity of periodic CSI-RS transmission due to LBT failure without specification change.

## 1st round discussion

Based on the above observations/proposals, summary of views on supporting beam management in unlicensed band in the table below.

### Summary of views on supporting beam management in unlicensed band

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 4 | Whether to enhance periodic RS transmissions to deal with LBT failure | Support enhancement on periodic RS transmissions to deal with LBT failure   * **Yes:** Lenovo/MotM, Nokia/NSB, CATT, LGE, Samsung, Apple, Convida * **No:** CATT   Alternatives if supported   * Termination of periodic RS transmission   + Lenovo/MotM * Dynamic switching of QCL assumption of periodic RS transmission   + Lenovo/MotM * Aperiodic TRS to patch a non-transmitted P-TRS   + Nokia/NSB, * Multiple transmission opportunities for TRS, CSI-RS and/or SRS   + Nokia/NSB, LGE * Multi-slot RS transmission by a single DCI   + Samsung, Apple |

### Observation

No clear majority was observed. Companies are requested to share their views on whether and how to enhance periodic RS transmissions to deal with LBT failure.

### Proposal 4

Further study at least for following enhancements on RS transmission to deal with LBT failure:

* Termination of periodic RS transmission
* Aperiodic RS transmission to patch a non-transmitted periodic RS (e.g., TRS, CSI-RS and BFD-RS)
* Dynamic switching of QCL assumption of periodic RS
* Multiple RS transmission opportunities
* Multi-slot RS transmission by a single DCI

### Additional inputs: issue 4

|  |  |
| --- | --- |
| **Company** | **Input** |
| Futurewei | Support FL’s Proposal 4. |
| Qualcomm | We are fine for Proposal 4 as starting point. |
| vivo | Fine to FFS. |
| Ericsson | We don’t think that this should be studied in this agenda item. There is ongoing discussion in 8.2.1 on whether or not to introduce DRS transmission window for SSBs. The discussion should not be duplicated here.  [Mod] I will discuss where to discuss this issue with Moderator of 8.2.1 and remove the proposal if it is determined to discuss this issue in 8.2.1  [Mod2] Based on the discussion, I will try to focus on the issues related RSs except SSBs |
| DCM | Support the proposal. |
| Samsung | We are ok with FL’s proposal. Maybe it’s good to list the concrete proposals for further study. For example, the alternatives listed in the FL summary could be part of the proposal for companies’ convenience for further study (of course other proposals are not excluded).  [Mod] Updated as requested |
| LG Electronics | OK to further study |
| Huawei, HiSilicon | Support FL’s Proposal 4 |
| ZTE, Sanechips | We are fine for FL’s Proposal 4. Besides, we think that a-periodic RS can be also considered as a solution to deal with LBT failure.  [Mod] removed “periodic” from the proposal |
| Moderator | Please check the updated proposal 4 based on the comments from Samsung and ZTE. |
| MediaTek | We are generally ok with current proposal. However, there is ongoing discussion on including CSI-RS as contention exempt short control signaling. If CSI-RS is considered as short control signaling without LBT, then do we still need the enhancements in this proposal? |
| Intel | We agree with Ericsson’s view  [Mod] Based on the discussion, I will try to focus on the issues related RSs except SSBs |
| Apple | Ok to study this. Note that this is for P/SP-CSI-RS, which is not coupled with SSB transmission. We had similar mechanisms defined for NR-U.  [Mod] This update is based on ZTE’s comments as they want to study aperiodic RS as well as periodic RS. For study, we can study RSs with possible transmission types and focus on desired transmission type for spec enhancement. |
| Lenovo, Motorola Mobility | Support the main proposal. Regarding the alternatives we support termination of periodic RS and/or dynamic switching of QCL type-D (beam) assumption for periodic RS  In our understanding, multiple QCL type-D (beam) assumption can be configured for each periodic RS transmission. If the LBT is failing for continuous number of transmissions above certain threshold, then the QCL type-D assumption is changed for that RS. This allows changing beams for periodic RS and without any additional dynamical signaling as might be required by other options such as aperiodic TRS to patch a non-transmitted P-TRS or multi-slot RS transmission by single DCI. |
| Nokia/NSB | Support FL’s proposal. |
| Convida Wireless | We support moderator’s proposal. |
| Xiaomi | Support proposal 4. |
| Huawei, HiSilicon | In the update proposal, some examples of the enhancements are listed to deal with the LBT failure. We think that either all examples should be removed or the list should be more comprehensive. In particular, at least two companies discussed the use of AP CSI-RS in BFR procedure to counter LBT failure. This needs to be included. Therefore, we propose to add the following bullet (note that a very similar bullet is already added to counter the LBT failure for P-TRS).   * Aperiodic CSI-RS transmission when LBT failure occurs on periodic BFD-RS /BFR-RS   [Mod] From Moderator point of view, the proposal from Huawei includes two parts as follows:   * First part: Aperiodic CSI-RS transmission when LBT failure occurs on periodic CSI-RS transmission * Second part: When UE is configured with periodic BFD-RS/BFR-RS and the RS fails, the UE uses corresponding aperiodic CSI-RS transmission.   For the first part, I think it can be discussed in this agenda, however, I feel that it would be better to discuss the second part in agenda 6.  In addition, as majority of companies are supporting further study, I feel that it would be better to discuss other proposals as well as the first part. |
| LG Electronics | Just to clarify, will this proposal be captured in FL summary for further discussion, or be summited to GTW session to make an agreement? For the latter case, the proposed lists should be refined to be clearer.  [Mod] I will submit the proposal if it is agreeable. I updated the list and please let me know if is still not clear enough. |
| Charter | Support Proposal 4 pending feedback from 8.2.1. |
| Sony | Generally, we are okay to further study the RS enhancement when LBT failure happens.  Besides periodic RS transmission impacted by LBT failure, is it possible that semi-persistent RS can also be impacted? If yes, it would be good to study the enhancement of both periodic and semi-persistent RS.  Next, we share similar view with Huawei on BFD RS, what about following wording. But if FL thinks this may belong to Proposal 5 in 6.2.3, we are also fine.   * Aperiodic TRS to patch a non-transmitted P-TRS * Aperiodic CSI-RS to patch a non-transmitted BFD-RS   [Mod] I updated the proposal to include both with one bullet as follows:   * Aperiodic RS transmission to patch a non-transmitted periodic RS (e.g., TRS, CSI-RS and BFD-RS) |
| DCM2 | We are fine with the updated proposal. |

# **Summary of Views on Supporting Beam Failure Recovery**

## Observations and Proposals from Contributions

### Timing enhancement

###### From [ZTE/Sanechips, 3]:

* + - The time for applying a new beam after receiving PDCCH with BFR response for the new supported SCS 480 kHz / 960 kHz may need to be re-considered.
    - The value of shortest periodicity for the physical layer to inform whether beam failure occurs should be re-considered for NR operation above 52.6 GHz.
    - Study and evaluate the impact of LBT and the limitation of COT length on the procedure of beam failure detection.

### Monitoring/candidate RS

###### From [OPPO, 4]:

* + - Holding the discussion on AP-CSI-RS for BFR/BFD until the LBT procedure has been made clear in agenda item 8.2.6.

###### From [Huawei/HiSi, 5]:

* + - 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.

###### From [Sony, 11]:

* + - Support aperiodic CSI-RS for beam failure detection (BFD) and candidate beam determination (CBD) at least for unlicensed band operation.

###### From [LGE, 12]:

* + - The following aspects can be considered to enhance beam management operation when channel access scheme is used for unlicensed spectrum.
      * How to provide more opportunities of CSI-RS or SRS transmission considering LBT failure
      * How to enhance beam failure procedure considering not transmitted BFD-RS due to LBT failure

###### From [Xiaomi, 13]:

* + - BFR procedure deeply relies on periodic CSI-RSs.
    - Study whether the BFR based on aperiodic CSI-RSs should be supported.
    - The BFR procedure based on semi-persistent CSI-RSs may need to be supported in NR-U-60-LBT.

###### From [NTT Docomo, 19]:

* + - Beam failure detection/recovery procedure in NR 52.6-71GHz can consider following enhancements,
      * FFS whether to increase the number of candidate beams included in set
      * FFS whether to introduce a larger time gap to apply new beam configuration after receiving BFR response from gNB
      * FFS monitoring aperiodic RS transmissions for beam failure detection

### Partial BFR

###### From [IDCC, 10]:

* + - 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.

###### From [Qualcomm, 18]:

* + - Support partial BFR for single TRP.

## 1st round discussion

Based on the above observations/proposals, summary of views on supporting beam failure recovery in the table below.

### Summary of views on supporting beam failure recovery

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 5.1 | Supporting efficient RS transmission/monitoring/selection for beam failure recovery | * **Yes:** Huawei/HiSi (AP-CSI-RS), Sony (AP-CSI-RS), IDCC, Xiaomi (SP-CSI-RS) * **No:** * **Hold the discussion until the LBT procedure is clear:** vivo |
| 5.2 | Defining new BFR related timings | * **Yes:** ZTE/Sanechip * **No:** |
| 5.3 | Supporting partial BFR for better reliability | * **Yes:** Qualcomm, IDCC * **No:** |

### Observation

No clear majority was observed. Companies are requested to share their views on BFR enhancements.

### Proposal 5

Further study whether or not enhancements to BFR for shared spectrum operation are needed.

### Additional inputs: issue 5

|  |  |
| --- | --- |
| **Company** | **Input** |
| Futurewei | Support FL’s Proposal 5. |
| Qualcomm | We are fine for Proposal 5 as starting point. |
| vivo | Fine to FFS. |
| Ericsson | We prefer to rephrase as "Further study whether or not enhancements to BFR are needed" Furthermore, the scope of enhancements should be defined – the WID says that it is only timing aspects that should be considered. Is it more than that? If the intention is to consider fundamental changes, then that should be handled in the feMIMO WI to avoid overlap.  [Mod] We also have the scope of enhancements with “specify if needed, potential enhancement for shared spectrum operation”. To identify whether it is needed or not, study is needed. |
| DCM | Support the proposal. |
| Samsung | To clarify, this proposal is for unlicensed operation only or in general for both operations? Current statement of the proposal is too broad, and at least the reasoning/issue should be captured. From our perspective, only issues due to new SCS and LBT should be included for further study in this agenda.  [Mod] Updated “shared spectrum operation” as indicated in the WID. |
| LG Electronics | To be in line with WID, BFR enhancement should focus on unlicensed band operation.  [Mod] Updated “shared spectrum operation” as indicated in the WID. |
| Huawei, HiSilicon | Generally supportive of FL’s proposal 5. However, we think that BFR should be replaced by BFD/BFR (Further study supporting enhancements on BFD/BFR) since they are not exactly the same process. In particular, our proposal considers BFD enhancements. Listing the possible enhancements mentioned in 5.1 to 5.3 in the agreement may also be useful.  [Mod] In my understanding, BFR includes beam failure detection (BFD), new beam identification, failure report and other procedures. |
| ZTE, Sanechips | Support FL’s Proposal 5 as a starting point for further study on BFR/BFD enhancement on licensed/unlicensed band. |
| Moderator | Please check the updated proposal based on the comments from Samsung and LGE. |
| MediaTek | Similar comment to proposal 4. There is ongoing discussion on including CSI-RS as contention exempt short control signaling. If CSI-RS is considered as short control signaling without LBT, then do we still need to further study BFR enhancement?  [Mod] In my understanding, yes. Currently, BFR only considers periodic CSI-RS and SSB as a monitoring RS. As you mentioned, CSI-RS may be enhanced, but it may be applicable if specification does not allow to configure the enhancement (e.g., aperiodic CSI-RS). |
| Intel | Although we understand the motivation for BFR enhancements, the proposed enhancements are generally applicable for beam management and could be handled within feMIMO WI. |
| Apple | We prefer the rephased proposal from Ericsson. In addition, the discussion should be triggered by concrete issues/proposals and avoid overlapping with FeMIMO WI.  [Mod] I updated proposal 4 based on your comment. On the scope, as the updated proposal clearly says BFR for shared spectrum, I don’t see any overlap with FeMIMO. |
| Lenovo, Motorola Mobility | Support Moderator’s proposal. At least for option 5.1 we agree to hold the discussion until the LBT procedure is clear for beam-based operation. |
| Nokia/NSB | BFR enhancement should be discussed later according to the enhancement of other features (e.g. RS transmission, PDCCH/PUCCH/PRACH design etc) |
| Convida Wireless | We support moderator’s proposal. |
| Xiaomi | We have question on the shared spectrum operation in proposal 5. Does it mean the unlicensed band operation considering only LBT mode channel access mechanism? If it does, we think the “shared spectrum operation” should be removed from proposal 5. Because, for the unlicensed band operation in 52.6-71GHz, both LBT mode and no-LBT mode channel access mechanism are recommended to be supported to cover a wide range of use cases and the BFR in both case may need some enhancements. |
| Moderator | Please check the updated proposal based on Apple’s comment. |
| Charter | Support Moderator’s Proposal 5 |
| Sony | Support FL’s proposal. |
| DCM2 | We are fine with the updated proposal. |

# **Summary of Views on Supporting Efficient Beam Management**

The following are observations/proposals related to supporting efficient beam management for NR in 52.6 – 71 GHz.

## Observations and Proposals from Contributions

### Handling increased number of beams due to narrower beamwidth

###### From [IDCC, 10]:

* + - 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.

###### From [Xiaomi, 13]:

* + - Beam management based on periodic reference signals for should be supported in NR-U-60-LBT.
    - The aperiodic CSI-RSs can be directly used to beam measurement if the number of beams is less than 64 in NR-U-6-LBT.
    - To support one CSI-reportConfig associsted with more than one aperiodic CSI-RS set, a new reporting mechanism is needed after the measurement on aperiodic CSI-RS triggered by DCI.
    - Semi-persistent CSI-RSs may be a substitute for periodic reference signals in NR-U-60-LBT.

###### From [Convida, 17]:

* + - For NR from 52.6 GHz to 71 GHz, beam management should be studied for the impact of narrower beamwidths on UE in idle/inactive states.

###### From [Qualcomm, 18]:

* + - Investigate sub-band based beam report.
    - The contents of configured TCI states can be dynamically updated.
    - Support dynamic beam update of periodic channel/RS.

###### From [NTT Docomo, 19]:

* + - 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.

### Beam related enhancements for initial access

###### From [Sony, 11]:

* + - Beam alignment during initial access procedure should be considered for NR above 52.6 GHz.

###### From [Qualcomm, 18]:

* + - Support UE report of recommended SSB in Msg3/A in initial access.

### Other enhancements

###### From [Apple, 16]:

* + - Support dynamic SR polling mechanism for above 52.6GHz frequency to reduce SR latency.

## 1st round discussion

For supporting efficient beam operation for NR in 52.6-71GHz, further inputs from companies are requested.

### Proposal 6

### Additional inputs: issue 6

|  |  |
| --- | --- |
| **Company** | **Input** |
| Futurewei | For supporting efficient beam management, this is clearly overlapping with R17 FeMIMO WID and the very reason to start with R17. Discussion/coordination with the FeMIMO WID are needed. |
| Qualcomm | Suggest to rephrase Proposal 6 as below. Because beam misalignment is a common issue in connected mode and may happen for other channels in addition to SR.  **Proposal 6**:  Further study following enhancements for NR in 52.6-71GHz:   * Beam management with increased number of beams * Beam management to mitigate beam misalignment for initial access and connected mode ~~dynamic SR polling mechanism~~ |
| vivo | Regarding these FFS points in proposal 6, we share the understanding that FeMIMO also discuss these aspects of beam management and like to echo the comment from Futurewei. |
| Ericsson | Regarding the first bullet, what does it mean "increased number of beams?" Increased # of SSB beams (the WID says maximum 64 as in FR2)? Or is it increase the # of configured TCI states (this was increased already in Rel-16 to 128 states)? Or does it mean increased # of CSI-RS resources in a set, or increased # of sets?  Generally, or view is that enhancements to basic beam management procedures should be discussed in feMIMO. Hence we don't agree with Qualcomm's modification. |
| DCM | We are fine with the first bullet.  For the second bullet, we are fine to consider beam management for initial access. But possible overlapping with AI8.2.1 for initial access should be clarified first. For dynamic SR polling, we don’t see strong motivation because it may introduce heavy DCI payload issue. |
| Samsung | We are ok with proposal, and agree with FUTUREWEI’s comment. Supporting Rel-17 BM for 52.6 to 71 GHz can avoid lot of duplicated work. |
| LG Electronics | We disagree with this proposal since it is out of the scope of WID. |
| Huawei, HiSilicon | Tend to agree with Futurewei on this. We believe that the list of enhancements in this Section is too wide and generally have a substantial overlap with Rel-17 MIMO enhancements. We prefer to discuss issues that are more isolated and specific to 71Ex at this stage. |
| ZTE, Sanechips | In principle, we agree with Proposal 6 from Moderator, but seems it is necessary to evaluate the necessity of the above enhancements and consider its priority. |
| Moderator | Further inputs from other companies are requested. |
| Intel | Here we think that the proposed beam management enhancements are general and could be handled within feMIMO WI as part of Rel-17 beam management. |
| Apple | We are ok with FL proposal. On the other hand, share views with other company to avoid overlapping with FeMIMO WI.  Regarding the SR polling proposed by us, it is really motivated to solve the misalignment problem of Tx/Rx beams between gNB and UE, which happens more frequency in heavily beam-formed system on >52.6GHz frequency band. Regarding the overhead, it really depends on the design details,e.g. a group-specific DCI maybe considered to trigger SR, instead of UE-specific. |
| Lenovo, Motorola Mobility | Agree with the proposal. Regarding beam management with increased number of beams, our reply from section 3 and 4 is copied here:  For beam switching time between signals/channels, our view is that it is mainly required when multiple PDSCH or multiple PUSCH are scheduled over multiple slots. In this case, multiple beams should be indicated and the duration for each beam should be indicated. For example, if 8 slots are indicated for PDSCH and 4 beams are indicated by TCI state. Then duration for each of the beams should be indicated as well. Such as if beam duration for each beam is 2 slots, then the beam switching is applied after every two slots (PDSCH transmissions). |
| Nokia/NSB | Need study for clarifying and selection of further enhancement scope.  It's not clear how dynamic SR polling relates to BM? It's a new procedure as such. |
| Xiaomi | We should focus on the problem of reusing the beam management procedure in Rel15/16 or Rel17 in NR from 52.6 GHz and 71GHz rather than the efficiency of beam management. |
| Charter | Tend to agree that beam management enhancements can be better handled in feMIMO. |
| Sony | We are open to study the beam management enhancement during initial access. But now the whole proposal is removed in updated FL summary, we are fine to discuss that later or in next meeting(s). |

# **References**

1. R1-2100052, “Beam management for shared spectrum access in Beyond 52.6GHz,” FUTUREWEI
2. R1-2100060, “Beam-management enhancements for NR from 52.6 GHz to 71GHz,” Lenovo, Motorola Mobility
3. R1-2100076, “Discussion on the beam management for 52.6 to 71GHz,” ZTE, Sanechips
4. R1-2100152, “Discussion on beam management,” OPPO
5. R1-2100203, “Discussion on the beam management procedures for 52-71GHz band,” Huawei, HiSilicon
6. R1-2100260, “Beam Management Aspects,” Nokia, Nokia Shanghai Bell
7. R1-2100373, “Beam management for new SCSs for up to 71GHz operation,” CATT
8. R1-2100432, “Discussions on beam management for new SCSs for NR operation from 52.6GHz to 71GHz,” vivo
9. R1-2100646, “Discussion on Beam management aspects for extending NR up to 71 GHz,” Intel Corporation
10. R1-2100839, “Discussions on beam management for new SCSs,” InterDigital, Inc.
11. R1-2100852, “Beam management enhancement for NR from 52.6GHz to 71GHz,” Sony
12. R1-2100895, “Enhancements for beam management to support NR above 52.6 GHz,” LG Electronics
13. R1-2101111, “Discussion on beam management in NR from 52.6 GHz to 71GHz,” Xiaomi
14. R1-2101197, “Beam management for new SCSs for NR from 52.6 GHz to 71 GHz,” Samsung
15. R1-2101309, “Beam Management for New SCSs,” Ericsson
16. R1-2101375, “On beam management for new SCSs,” Apple
17. R1-2101419, “On Beam Management for Supporting NR from 52.6 GHz to 71 GHz,” Convida Wireless
18. R1-2101456, “Beam management for new SCS for NR in 52.6 to 71GHz band,” Qualcomm Incorporated
19. R1-2101608, “Beam based operation for new SCSs for NR from 52.6 to 71 GHz,” NTT DOCOMO, INC..