**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]**

**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.

* 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.

**Discussion 1:**

Based on the above observations/proposals, summary of views on a basis of beam-based operation is provided in Table 1.

**Table 1** 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 1**:

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, Rel-15/16 beam management is assumed as a basis.

**Table 2** 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. |
| 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.
 |
| 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.  |
| 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. |

# **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.

* 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.

**Discussion 2:**

Based on the above observations/proposals, summary of views on supported timings associated with beam-based operation is provided in Table 3.

**Table 3** Summary of views on supported timings associated with beam-based operation for new SCSs

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| --- | --- | --- |
| **#** | **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 2**:

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,

* 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
* Companies are encouraged to provide preferred values on timeDurationForQCL, beamSwitchTiming, beamSwitchTiming-r16 and beamReportTiming in RAN1#104bis-e

**Table 4** 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. |
| 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
 |
| 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. |
| 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.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.We are supportive of revisiting the value of the beam switch count parameter mentioned by Qualcomm. |
| 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.  |
| 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.
* 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.
* 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”.
 |
| 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.  |
| 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. |

# **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.

* 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 [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 [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 [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.

**Discussion 3:**

Based on the above observations/proposals, summary of views on supporting multiple beams for multiple PDSCHs is provided in Table 5.

**Table 5** 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, ~~Huawei/HiSi~~
* **Multiple beams:** Lenovo/MotM, CATT, Samsung, Convida
 |

**Observation 3:**

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 supporting multiple beams for multiple PDSCHs scheduled by a single DCI.

**Table 6** 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.  |
| 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.  |
| 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
 |
| 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. |
| 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.”* |

# **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.

* 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.

**Discussion 4:**

Based on the above observations/proposals, summary of views on supporting beam management in unlicensed band in Table 7.

**Table 7** 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 4:**

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 supporting enhancements on periodic RS transmission to deal with LBT failure.

**Table 8** 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. |
| 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).  |
| 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. |

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

* 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.

**Discussion 5:**

Based on the above observations/proposals, summary of views on supporting beam failure recovery in Table 9.

**Table 9** 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 5**:

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

**Proposal 5**:

Further study supporting enhancements on BFR.

**Table 10** Additional inputs: issue 6

|  |  |
| --- | --- |
| **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. |
| 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.  |
| LG Electronics | To be in line with WID, BFR enhancement should focus on unlicensed band operation. |
| 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.  |
| ZTE, Sanechips | Support FL’s Proposal 5 as a starting point for further study on BFR/BFD enhancement on licensed/unlicensed band. |

# **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.

* 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.

**Discussion 6:**

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

**Proposal 6**:

Further study following enhancements for NR in 52.6-71GHz:

* Beam management with increased number of beams
* Beam management for initial access and dynamic SR polling mechanism

**Table 12** 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. |

# **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..