**3GPP TSG RAN WG1 Meeting #103-e R1- 2009668**

**e-Meeting, October 26 – November 13, 2020**

**Source: Moderator (Intel Corporation)**

**Title: Summary of 38.808 TR Text Proposal Discussion**

**Agenda item: 8.2.1**

**Document for: Discussion**

# Introduction

This document is to facilitate discussion of text proposal for the TR38.808. Please note evaluation assumption related agreement made in the previous meeting should have been already incorporated in the endorsed TR and is omitted in the discussion below.

# Agreements from RAN1 #101-e and #102-e

### Agreement #1:

For NR system operating in 52.6 GHz to 71 GHz,

* NR should be designed with maximum FFT size of 4096 and maximum of 275RBs per carrier;
* Candidate supported maximum carrier bandwidth(s) for a cell is between 400 MHz and 2160 MHz;
* If subcarrier spacing 240 kHz or below are supported, NR in 52.6 to 71 GHz is expected to use normal CP length only (does not have any implications on whether ECP is supported for the higher subcarrier spacings, if supported).

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):*****Agreement #45 should cover the agreement and no further update is needed.*** In order to minimize specification effort while maximizing supported use cases and deployment scenarios applicable for 52.6 GHz to 71 GHz frequency, It is recommended to support 120 kHz subcarrier spacing with normal CP length, and at least one more subcarrier spacing. It is recommended to consider supporting at most up to three subcarrier spacings, including 120 kHz subcarrier spacing. Applicability of the supported subcarrier spacing to particular signals and channels should be further discussed in the corresponding WI phase.
* It is recommended that numerologies 240 kHz, 480 kHz, and 960 kHz are considered as candidates for additional numerologies in addition to 120 kHz, and numerologies outside this range are not supported for any signals or channels.
* In order to bound implementation complexity, it is recommended to limit the maximum FFT size required to operate system in 52.6 GHz to 71 GHz frequency to 4096 and to limit the maximum of RBs per carrier to 275 RBs.

**[Updated]****Add following text to where agreement #45 is captured.*** + **The candidate supported maximum carrier bandwidth(s) for a cell should be between 400 MHz and 2160 MHz.**
	+ **It is recommended that for subcarrier spacing 240 kHz or below, normal CP length is utilized for candidate subcarrier spacings.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | Suggest to wait for the updated agreement being discussed under 8.2.1. |
| Ericsson | Agree with comment from Huawei |
| Huawei2, HiSilicon2 | Agreement #45 does not reflect that NCP will be used with 240 kHz SCS if it is adopted as an additional subcarrier spacing.  |
| Moderator | Yes. I agree with HW, just noticed this. We should keep the NCP agreement and the maximum BW text. |
| Nokia, NSB | Disagree, we discussed channel BW further in RAN1#103 and in Agreement #58: we observedSome companies have observed that channelization based on granularity of minimum supported channel BW would be benefitial and could provide efficient usage of available spectrum. Other companies have observed that support of channel BW such as 1.6 GHz or 2.4GHz would enable efficient usage of 5 GHz allocation in China and 5 GHz IMT allocation in EuropeTherefore we think that 102 agreement **is replaced by new** Agreement #58 |
| Ericsson 2 | Agree with update from moderator.We don't think that the observation in Agreement #58 replaces the agreement on candidate supported maximum BWs in Agreement #1. |
| Moderator | Because we were making agreements here and there, I realize the overall text isn’t great looking. However, the current doesn’t seem to contradict as I understand. If so, I think it would be preferrable to keep things the way they are. Agreement #58 is general companies observations, and Agreement #1 is a agreement in RAN1.  |

### Conclusion #2:

RAN1 continues study and specification effort for both licensed and unlicensed operation for supporting NR from 52.6 GHz to 71 GHz SI.

* RAN1 strives for maximum commonality for the system design for licensed and unlicensed operation for NR from 52.6GHz to 71GHz, and for maximum re-use of the existing NR design

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under 4.1.1 General description of study in RAN1**
	* **It is recommended to strive for maximum commonality for the system design for licensed and unlicensed operation for NR from 52.6GHz to 71GHz, and maximize re-use of the existing NR design.**

**Moderator note: Not entire sure if the conclusion should be captured in TR or not. Please provide comments on what you think.** |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We agree to capture this conclusion in the TR. |
| Ericsson  | Agree to capture conclusion |

### Agreement #3:

* Instruct rapporteur to create dedicated (sub-)section for set of identified issues for physical layer NR design.
* Endorse following text proposal as introduction to the (sub-)sections for discussing identified issues for physical layer.
	+ For supporting NR operation in both licensed and unlicensed band in the frequency range from 52.6 GHz to 71 GHz, FR2 numerologies and additional numerologies beyond that supported currently in NR are studied. Existing framework for numerology scaling is considered i.e. 2μ ×15 subcarrier spacing to select the candidates. For SSB transmissions, it is investigated whether or not µ>4 (larger than 240 kHz) is needed and corresponding impacts, if any, on the aspects including at least SSB pattern, multiplexing of other signal/channels, and transmission window, if supported. For data and control channel transmissions, it is investigated if µ>3 (larger than 120 kHz) is needed and corresponding impacts, if any, on aspects including at least processing timelines, PDCCH monitoring capability (BD/CCE), scheduling enhancements, beam-management, and reference signal design. For investigating the need for higher numerologies, some of the key aspects that are studied are the impacts due to phase noise, delay spread, TAE, analog beam switching delay, and impact to coverage, spectral efficiency and peak data rates, and relative delay in intra-cell/inter-cell multi-TRP operations.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion:***1. **Capture as is (text above) under 4.1.1 General description of study in RAN1**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | Agree |
| Ericsson | Agree |
| Lenovo, Motorola Mobility | Editorial update :..For investigating the need for higher numerologies, some of the key aspects that are studied are the impact**s** due to phase noise, delay spread, TAE, analog beam switching delay, and impact to coverage, spectral efficiency and peak data rates, and relative delay in intra-cell/inter-cell multi-TRP operations. |
| Moderator | Will update based on Lenovo’s comments. |
| Apple | Editorial Updates:* + For supporting NR operation in both licensed and unlicensed bands in the frequency range from 52.6 GHz to 71 GHz, FR2 numerologies and additional numerologies beyond that are supported currently in NR are studied. The existing framework for numerology scaling is considered, i.e. 2μ ×15 subcarrier spacing, to select the candidates. For SSB transmissions, it is investigated whether or not µ>4 (larger than 240 kHz) is needed and the corresponding impacts, if any, on aspects including at least SSB pattern, multiplexing of other signal/channels, and transmission window, if supported. For data and control channel transmissions, it is investigated if µ>3 (larger than 120 kHz) is needed and the corresponding impacts, if any, on aspects including at least processing timelines, PDCCH monitoring capability (BD/CCE), scheduling enhancements, beam-management, and reference signal design. For investigating the need for higher numerologies, some of the key aspects that are studied are the impacts due to phase noise, delay spread, TAE, analog beam switching delay, and impact to coverage, spectral efficiency, peak data rates, and relative delay in intra-cell/inter-cell multi-TRP operations.
 |
| Moderated | Updated as suggested by Apple in v11. |

### Agreement #4:

* Study whether or not different SSB patterns should be supported for licensed and unlicensed bands.
* For each licensed and unlicensed band, if issues are identified for reuse of existing SSB, consider at least the following aspects for SSB
	+ Beam switching gap between SSB(s) and between SSB and other signal(s)/channel(s)
	+ SSB pattern in time domain
	+ Whether or not it is needed to define a transmission window (such as DRS window), and if needed, number of SSB transmission opportunities within a transmission window
* For each licensed and unlicensed band, if issues are identified for reuse of all or some of the existing SSB and CORESET#0 multiplexing pattern, consider at least the following aspects for SSB, CORESET#0, and other signal/channel design
	+ Supported multiplexing pattern type(s) (Pattern 1, 2, and/or 3) for SSB and CORESET#0 multiplexing.
	+ Multiplexing of other signal/channels (e.g. RMSI, paging, CSI-RS) with SSB
	+ Configuration of Type0-PDCCH search space set

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapportuer has yet to provide a correspoding TP for this agreement. Rapportuer assumes agreement should be captured in some form to correctly represent progress made in RAN1 and RAN4. Please comment on whether you think the agreement should be not captured in some form to the TR or if you have suggestions on how this can be captured.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We may want to revisit later since we are still discussing related recommendations for SSB under 8.2.1, and many of the aspects are overlapping or repeating. |
| Ericsson | Agree with Huawei. We should wait and then consolidate SSB-related agreements from this meeting |
| Moderator | Understood. Will provide further suggestion once rest of the agreement for SSB is completed. |

### Agreement #5:

RAN1 at least considers the following aspects for determination of supported SSB subcarrier spacing

* Detection performance of SSB (including PSS, SSS, PBCH DMRS, and PBCH) and SSB coverage requirement
* Impact on initial cell search complexity due to frequency errors (e.g. carrier frequency offset, Doppler shift, etc)
* Timing detection accuracy and its relation to uplink transmission accuracy
* Signaling design for supporting different subcarrier spacing for SSB and CORESET#0 (if supported)
* Multi-TRP delay considerations
* Consideration of SSB-based RRM/RLM and beam management if the SSB SCS is significantly different from that of the active BWP (e.g., switching gap, scheduling constraint, etc.)

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture following to Section 4.1.3.2**

For determination of supported SSB subcarrier spacing, the following aspects are at least considered* detection performance of SSB (including PSS, SSS, PBCH DMRS, and PBCH) and SSB coverage requirement,
* impact on initial cell search complexity due to frequency errors (e.g. carrier frequency offset, Doppler shift, etc),
* timing detection accuracy and its relation to uplink transmission accuracy,
* signaling design for supporting different subcarrier spacing for SSB and CORESET#0 (if supported),
* multi-TRP delay considerations,
* consideration of SSB-based RRM/RLM and beam management if the SSB SCS is significantly different from that of the active BWP (e.g., switching gap, scheduling constraint, etc.).
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We think the agreement should be captured, as it lists various criteria for the determination of SSB SCS, and it is so far the only complete agreement/observation that lists all those criteria. |
| Ericsson | Agree to capture |
| moderator | Updated as suggested. Flags to the agreements are available if we need to change. |
| Apple | For determination of supported SSB subcarrier spacing, the following aspects are at least considered4th bullet: Timing |
| Interdigital | In section 4.1.2, the paragraph capturing Agreement #5 has problems on using bullets. |
| Moderator | Updated as suggested by Apple in v11. Corrected error pointed out by Interdigital. |
| Huawei | In section 4.1.2.1, the paragraph and bullet list starting with “For determination of supported SSB subcarrier spacing, the following aspects are at least considered:” may fit better under 4.1.3.2? |
| Moderator | Moved to 4.1.3.2 |

### Agreement #6:

Consider the at least following aspects for PRACH design of NR operating in 52.6 GHz to 71 GHz

* PRACH coverage requirements
* applicable PRACH Sequence length(s) and subcarrier spacing(s) for PRACH, including any impact on PRACH coverage and capacity from the applicable sequence length(s).
* RACH RO configurations with new SCS (if new SCS is supported)
* LBT gap between RACH occasions (RO)

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):******From the agreement #6, the following aspects are covered by new agreements made in RAN1 #103-e***Consider the at least following aspects for PRACH design of NR operating in 52.6 GHz to 71 GHz* PRACH coverage requirements
* applicable PRACH Sequence length(s) and subcarrier spacing(s) for PRACH, including any impact on PRACH coverage and capacity from the applicable sequence length(s). 🡪 Moderator comment: already covered by Agreement #60
* RACH RO configurations with new SCS (if new SCS is supported)
* LBT gap between RACH occasions (RO) 🡪 Moderator comment: already covered by Agreement #60

***So I suggest to capture the bullet points not covered.***1. **Capture the following in 4.1.3.2**
* **Further studies on RACH occasion configurations with new SCS, if new SCS for PRACH is supported, is needed.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We think the agreement should be captured, and may need to consider related agreements made at RAN1#103e in order to avoid repetitions/overlap. |
| Ericsson | This agreement should be merged with agreements from this meeting |
| Moderator | Updated to capture the non-overlapped part as mentioned above. |
| Ericsson 2 | **The part about coverage is already covered by the last bullet of Agreement #60 which is captured in Section 4.1.3.2, so suggest modifying this as follows:****Further studies on ~~PRACH coverage requirements,~~ RACH occasion configurations with new SCS, if new SCS for PRACH is supported, is needed.** |
| Moderator | **Updated as suggested by Ericsson.** |

### Agreement #7:

Consider at least the following aspects of PT-RS design for a given SCS

* Phase noise compensation performance of existing PT-RS design
* Study of need of any modification/changes to existing PT-RS design
	+ Potential modification to the PT-RS pattern or configuration to aid performance improvement for CP-OFDM and DFT-s-OFDM waveforms (if needed)
	+ Potential methods to aid ICI compensation at the receiver (if needed)

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapportuer has yet to provide a correspoding TP for this agreement. Rapportuer assumes agreement should be captured in some form to correctly represent progress made in RAN1 and RAN4. Please comment on whether you think the agreement should be not captured in some form to the TR or if you have suggestions on how this can be captured.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | As commented under 8.2.1, we suggest that RAN1 recommends to investigate and specify the type of PTRS enhancements needed for supporting large MCS with ICI compensation, for all supported SCS. |
| Ericsson | A TP can be generated taking into account observations/conclusions reached in this meeting on performance in the 8.2.3 AI. Our view is that Rel-15 PT-RS performs well, and any enhancements need to be well-motivated. |
| Moderator | Some overlap description is being discussed in RAN1#103-e, let wait for that outcome first. |

### Agreement #8:

Consider at least the following aspects of DM-RS design for a given SCS

* Channel estimation performance of existing DM-RS design with existing and new SCSs (if any)
* Study whether there is a need of any modification/changes to existing DM-RS design
	+ Potential modification or introduction of new DM-RS pattern, configuration or indication to aid performance improvement for CP-OFDM and DFT-S OFDM waveforms (if needed)

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapportuer has yet to provide a correspoding TP for this agreement. Rapportuer assumes agreement should be captured in some form to correctly represent progress made in RAN1 and RAN4. Please comment on whether you think the agreement should be not captured in some form to the TR or if you have suggestions on how this can be captured.**
 |
|  **Company** | **Comments** |
| Ericsson | A TP can be generated taking into account observations/conclusions reached in this meeting on performance in the 8.2.3 AI.Our view is that Rel-15 DMRS is operational, and it is FFS whether or not enhancements are needed, particularly for the largest SCS. |
| Moderator | Some overlap description is being discussed in RAN1#103-e, let wait for that outcome first. |

### Agreement #9:

Consider at least the following aspects of processing timelines for new SCS (if agreed) that are not currently supported,

* appropriate configuration(s) of k0, k1, k2,
* PDSCH processing time (N1),
* PUSCH preparation time (N2),
* HARQ-ACK multiplexing timeline (N3)
* CSI processing time, Z1, Z2, and Z3, and CSI processing units
* Any potential enhancements to CPU occupation calculation
* Related UE capability(ies) for processing timelines
* minimum guard period between two SRS resources of an SRS resource set for antenna switching

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapportuer has yet to provide a correspoding TP for this agreement. Rapportuer assumes agreement should be captured in some form to correctly represent progress made in RAN1 and RAN4. Please comment on whether you think the agreement should be not captured in some form to the TR or if you have suggestions on how this can be captured.**
2. **Note: part of this may be covered by TP by the email discussion thread #1**
 |
|  **Company** | **Comments** |
| Ericsson | This agreement should be merged with related agreements made in this meeting |
| Moderator | There is significant overlap with #62, not sure if something in #62 is missing something that is captured here. Will wait for further feedback. |

### Agreement #10:

Consider at least the following aspects of PDCCH monitoring for a given SCS

* For new SCS, if agreed, that are not supported in Rel-15/16 NR,
	+ investigate on the maximum number of BDs/CCEs for PDCCH monitoring per time unit
		- e.g. slot as Rel-15, or new scheduling/monitoring unit
	+ any potential limitation to PDCCH monitoring configurations (e.g. search spaces, DCI formats, overbooking/dropping, etc) to help with UE processing, if needed
		- e.g. increased minimum PDCCH monitoring unit
	+ potential enhancements for CORESET, if needed
	+ related UE capability(ies) for PDCCH processing

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture the following in Section 4.1.3.4.**
* For new SCS for PDCCH, if agreed, that are not supported in Rel-15/16 NR, consider the following aspects:
	+ investigate on the maximum number of BDs/CCEs for PDCCH monitoring per time unit, e.g. slot as Rel-15, or new scheduling/monitoring unit,
	+ any potential limitation to PDCCH monitoring configurations (e.g. search spaces, DCI formats, overbooking/dropping, etc) to help with UE processing, if needed, e.g. increased minimum PDCCH monitoring unit,
	+ potential enhancements for CORESET, if needed,
	+ related UE capability(ies) for PDCCH processing.
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | It would be good to capture this agreement in order to keep track of the specification effort for new SCS, so that a complete WID can be provided to TSG RAN. |
| Ericsson | This agreement should be merged with related agreements made this meeting |
| Moderator | Updated as suggested above. The TR contain tags to identify this change so that we can modify or delete (if needed) later. |

### Agreement #11:

Consider at least the following aspects of scheduling for BWP with a given SCS

* Study of frequency domain scheduling enhancements/optimization for PDSCH/PUSCH, if needed
	+ e.g. potential impact to UL scheduling if frequency domain resource allocation with different granularity than FR1/2 (e.g. sub-PRB, or more than one PRB) is supported
* Study of time domain scheduling enhancements for PDSCH/PUSCH, if needed
	+ e.g. increasing the minimum time-domain scheduling unit to be larger than one symbol, supporting multi-PDSCH scheduled by one DCI, supporting one TB mapped to multiple slots (i.e., TTI bundling)
* Study potential enhancements or alternatives to the scheduling request mechanism to reduce scheduling latency due to beam sweeping, if needed

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):******Among the agreements the following issue seems to be resolved by RAN1 agreement in 103e.*** * Study of frequency domain scheduling enhancements/optimization for PDSCH/PUSCH, if needed
	+ e.g. potential impact to UL scheduling if frequency domain resource allocation with different granularity than FR1/2 (e.g. sub-PRB, or more than one PRB) is supported
* Study of time domain scheduling enhancements for PDSCH/PUSCH, if needed
	+ e.g. increasing the minimum time-domain scheduling unit to be larger than one symbol, supporting multi-PDSCH scheduled by one DCI, supporting one TB mapped to multiple slots (i.e., TTI bundling) 🡪 **Moderator comment: this seems to be covered by agreement #62**
* Study potential enhancements or alternatives to the scheduling request mechanism to reduce scheduling latency due to beam sweeping, if needed

***Suggest to capture the non-overlapped portions.***1. **Do not capture the text below. Overlap with agreemetn #62.**

Further study of frequency domain scheduling enhancements oroptimization for PDSCH/PUSCH e.g. potential impact to UL scheduling, if frequency domain resource allocation with different granularity than what is support for FR1 and FR2 such as sub-PRB or more than one PRB is supported, and further study whether such enhancements or optimization are needed.1. **Capture the following in Section 4.1.3.7**

**Further study potential enhancements or alternatives to the scheduling request mechanism to reduce scheduling latency due to beam sweeping** and further study whether such enhancements or alternative are needed**.** |
|  **Company** | **Comments** |
| Huawei, HiSilicon | It seems those study objectives may become superceded by later agreements/observations on the ”if needed” parts. We suggest deferring drafting a TP until those agreements are made under 8.2.1. |
| Ericsson | Agree with Huawei – agreements from this meeting may be more complete |
| Moderator | Update the TR capturing the components that is not overlaping with agreement from RAN1 #103e (as suggested above). |
| Ericsson 2 | Editorial comment:Adding the words "and the need for such enhancements or optimizations is needed" at the end of the sentence seems to be a bit unclear. I think your intention is to study whether there is a need for such enhancements. Maybe change to "and further study whether such enhancements or optimizations are needed" |
| Huawei | In section 4.1.3.3, the first paragraph seems to answer the “further study” from the second paragraph. Is the second paragraph still needed? *Moderator Notes: second paragraph above from Huawei refers to first part of agreement #11* |
| Moderator | Updated as suggested by Ericsson.Deleted first portion of the #11 from TR as suggested by Huawei. |

### Agreement #12:

Consider at least the following aspects for uplink transmission

* Study of potential enhancements for PUSCH/PUCCH/PRACH transmissions to achieve higher transmit power (when transmit power spectral density limits apply), if needed
* Study whether uplink interlace needs to be supported for unlicensed operation in 60 GHz band.
	+ If supported, study uplink PRB and/or sub-PRB based interlace design for PUCCH, PUSCH, and/or SRS.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapportuer has yet to provide a correspoding TP for this agreement. Rapportuer assumes agreement should be captured in some form to correctly represent progress made in RAN1 and RAN4. Please comment on whether you think the agreement should be not captured in some form to the TR or if you have suggestions on how this can be captured.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | It seems those study objectives may become superceded by later agreements/observations on the ”if needed” parts. We suggest deferring drafting a TP until those agreements are made under 8.2.1. |
| Ericsson | Should be merged with related agreement from this meeting |
| Moderator | Understood, should wait for further outcome on PUCCH from this meeting and merge if needed. PRACH and PUSCH components has been already captured by agreements in RAN1 #103e and no need to capture further. |

### Agreement #13:

* Study single carrier and multi carrier operations for achieving wide bandwidth utilization, while at least considering aspects such as control signaling overhead, transceiver complexity, spectral efficiency, etc.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapportuer has yet to provide a correspoding TP for this agreement. Rapportuer assumes agreement should be captured in some form to correctly represent progress made in RAN1 and RAN4. Please comment on whether you think the agreement should be not captured in some form to the TR or if you have suggestions on how this can be captured.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We believe CA should continue being supported, it is business as usual, and thus the TR could simply recommend to support CA. |
| Ericsson | We can capture that both single and multi-carrier operation are supported in the spec today, and there is no need to preclude either – business as usual as Huawei mentions. |
| Moderator | Understood, will wait for further outcome from multi-carrier section from this meeting, and merge if needed. |

### Agreement #14:

Consider at least the following aspects in system operations with beams

* Study of BFR mechanism enhancements, if supported
	+ e.g., the use of aperiodic CSI-RS for BFR, increased number of RSs for monitoring/candidates and efficient utilization of the increased number of RSs, enhanced reliability to cope with narrower beamwidth
* Study of UE capabilities on beam switch timing in beam management procedure
* Study of enhancements for beam management and corresponding RS(s) in DL and UL are needed further considering at least the following aspects, if supported:
	+ beam switching time, beam alignment delay (including initial access), LBT failure, and potential coverage loss (if large SCS is supported)
* Study of beam switching gap handling for signals/channels (e.g. CSI-RS, PDSCH, SRS, PUSCH) for higher subcarriers spacing, if supported

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture in Section 4.1.3.7**

For system operations with beams, consider at least the following aspects:* study of BFR mechanism enhancements, including whether such enhancements should be supported
	+ e.g., the use of aperiodic CSI-RS for BFR, increased number of RSs for monitoring/candidates and efficient utilization of the increased number of RSs, enhanced reliability to cope with narrower beamwidth
* study of UE capabilities on beam switch timing in beam management procedure
* study of enhancements for beam management and corresponding RS(s) in DL and UL are needed further considering at least the following aspects, including whether such enhancement should be supported:
	+ beam switching time, beam alignment delay (including initial access), LBT failure, and potential coverage loss (if large SCS is supported)
* study of beam switching gap handling for signals/channels (e.g. CSI-RS, PDSCH, SRS, PUSCH) for higher subcarriers spacing, including whether such switching gap handling should be supported
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | It seems those study objectives may become superceded by later agreements/observations on the ”if supported” parts. We suggest deferring drafting a TP until those agreements are made under 8.2.1. |
| Ericsson | Should be merged with related agreements from this meeting |
| Moderator | From the left over proposal for RAN1 #103e, its looks like non of the proposals are overlapping with this agreement.  |
| InterDigital | We agree with Moderator that non of the proposals are overlapping with this agreement |

### Agreement #15:

* Consider the study of at least the following aspects, including the justification for the features and their potential benefits, if applicable
	+ System overhead impact from TDD switching time for larger subcarrier spacing
	+ Coverage enhancement mechanisms for control channels and SSB, if larger SCS is supported
	+ Any potential modifications to HARQ processes including number of processes, if supported
	+ Impact from MAC buffering for larger subcarrier spacing, if any
	+ NR channelization/sub-channelization and any potential impact from RAN1 perspective
	+ Additional RF impairments that impact evaluations
	+ Impact on BWP switching procedure due to new higher SCS, if supported
	+ Support of rank 2 transmission for DFT-s-OFDM in the uplink
* Other aspects and impacts due to introduction of higher SCS are not precluded.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture in Section 4.1.1.**
* The following aspects (but not limited to), including the justification for the features and their potential benefits, if applicable, were investigated by companies:
	+ system overhead impact from TDD switching time for larger subcarrier spacing,
	+ any potential modifications to HARQ processes including number of processes, if supported,
	+ NR channelization/sub-channelization and any potential impact from RAN1 perspective,
	+ additional RF impairments that impact evaluations,
	+ impact on BWP switching procedure due to new higher SCS, if supported,
	+ support of rank 2 transmission for DFT-s-OFDM in the uplink,
	+ other aspects and impact due to introduction of higher SCS.
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | Such types of agreements may be turned into TPs of the sort: ”RAN1 studied the following aspects...” and list only those that were indeed studies and for which observations were agreed. |
| Ericsson | Agree with comment from Huawei |
| Moderator | Updated as above. I’ve tagged the text correponding to this in the TR, so that we can edit or delete if needed. |
| Ericsson 2 | It seems not all bullets have observations that were agreed, so some can be deleted? |
| Huawei | In section 4.1.1 there is a list of items that are claimed to have been investigated. However some of those items don’t have any corresponding observation or conclusions during the study, other than the initial agreement to consider studying those aspects, so we suggest removing them from the list: * Coverage enhancement mechanisms for control channels and SSB, if larger SCS is supported
* impact from MAC buffering for larger subcarrier spacing, if any
* any potential modifications to HARQ processes including number of processes, if supported,
* support of rank 2 transmission for DFT-s-OFDM in the uplink
 |
| Nokia | In section 4.1.1 there is a list of items that are claimed to have been investigated. However some of those items don’t have any corresponding observation or conclusions during the study, other than the initial agreement to consider studying those aspects, so we suggest removing them from the list: * Coverage enhancement mechanisms for control channels and SSB, if larger SCS is supported

Nokia: Corresponding agreements were made for this aspects.* impact from MAC buffering for larger subcarrier spacing, if any
* any potential modifications to HARQ processes including number of processes, if supported,
* support of rank 2 transmission for DFT-s-OFDM in the uplink

Nokia: in fact one company studied and observed that *Due to phase noise, Rank-2 SU-MIMO for DFT-s-OFDM is significantly better than rank-1 transmission in achieving good throughput with reasonable coverage.*Results are in Figure 12 of R1-2007926 |
| Moderator | Let’s keep the rank 2 bullet as it was in fact investigated by at least one company.For the number of HARQ processes, I see that there are few companies who noted some discussion in the contributions.I don’t have the bets memory, but MAC bufferring issues, I don’t recall anything specific. So maybe this is ok to remove.Coverage enhancement part, I think we can remove as wellI suggest to delete the following:* Coverage enhancement mechanisms for control channels and SSB, if larger SCS is supported
* impact from MAC buffering for larger subcarrier spacing, if any

To Ericsson and Huawei: were there any others that you think we should remove. Please suggest further |

### Conclusion #16:

The OCB requirement of draft version v2.1.20 of EN 302 567 implies that

* Device supports one or multiple declared nominal channel bandwidths.
* For each declared nominal channel bandwidth, RAN1 design should support at least one physical layer signal/channel transmission that occupies at least 70% of the nominal channel bandwidth.
* FFS: Mapping of nominal channel bandwidth to bandwidth definitions in NR.

### Conclusion #17:

The RAN1 understanding of the CCA check procedure in draft v2.1.20 of EN 302 567 is as follows:

* When performing CCA before initiating transmission, during count down, when an observation slot fails ED, the counter freezes, and will continue count down 8us after the interference is detected to be gone

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.1**

The OCB requirement of draft version v2.1.20 of EN 302 567 [4] implies that * device supports one or multiple declared nominal channel bandwidths,
* for each declared nominal channel bandwidth, RAN1 design should support at least one physical layer signal/channel transmission that occupies at least 70% of the nominal channel bandwidth.

Mapping of nominal channel bandwidth to bandwidth definitions in NR should be further studied when specifications are developed.The RAN1 understanding of the CCA check procedure in draft v2.1.20 of EN 302 567 is as follows:* when performing CCA before initiating transmission, during count down, when an observation slot fails ED, the counter freezes, and will continue count down 8us after the interference is detected to be gone.
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We believe that Conclusion # 16 needs to be captured in TR minus the FFS part. If RAN1 makes an agreement regarding nominal channel bandwidth, that agreement may follow conclusion #16 in the TR. We believe that Conclusion #17 needs to be captured in TR. |
| Ericsson | Should be captured in the TR |
| Lenovo, Motorola Mobility | Editorial update:Mapping of nominal channel bandwidth to bandwidth definitions in NR should be further studied~~s~~ when ~~when~~ specifications are developed. |
| Moderator | Updated as suggested by Lenovo. |

### Agreement #18:

* For gNB/UE to initiate a channel occupancy, both channel access with LBT mechanism(s) and a channel access mechanism without LBT are supported
* FFS: LBT mechanisms such as Omni-directional LBT, directional LBT and receiver assisted LBT type of schemes when channel access with LBT is used.
* FFS: If operation restrictions for channel access without LBT are needed, e.g. compliance with regulations, and/or in presence of ATPC, DFS, long term sensing, or other interference mitigation mechanisms
* FFS: The mechanism and condition(s) to switch between channel access with LBT and channel access without LBT (if local regulation allows)

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.2**
	* **It is recommended to support both channel access with LBT mechanism(s) and a channel access mechanism without LBT for gNB and UE that initiate a channel occupancy. Further investigation of the following issues may be needed:**
		+ **LBT mechanisms such as omni-directional LBT, directional LBT, and receiver assisted LBT type of schemes when channel access with LBT is used,**
		+ **whether operation restrictions for channel access without LBT are needed, e.g. compliance with regulations, and/or in presence of ATPC, DFS, long term sensing, or other interference mitigation mechanisms, and**
		+ **the mechanism and condition(s) to switch between channel access with LBT and channel access without LBT (if local regulation allows)**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | In general, OK to capture the first bullet. However, subbulets of Bullet 1 may be updated by the possible future agreements in RAN1 103-e. Also, the intenion of the second bullet is unclear and we suggest to remove it at this time. |
| Ericsson | Okay to capture first bullet. The sub-bullets may be superceded by agreements from this meeting. |
| Apple | The term ”futher studies” may be misleading as it may be construed as an extension of the study item. ”Futher investigation/discussion”? |
| Moderator | Will update to ”investigate” for may need to update based on additional agreement from channel access this meeting. |
| Huawei/HiSilicon3 | We suggest the following change to align it with the actual text of the agreement:* + **It is recommended to support both channel access with LBT mechanism(s) and a channel access mechanism without LBT for gNB and UE to initiate a channel occupancy**
 |

### Agreement #19:

Use the LBT procedures in draft v2.1.20 of EN 302 567 as the baseline system evaluation with LBT

* Enhancements to ED threshold, contention window sizes etc. can be considered as part of the evaluations.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Rapporteur’s understanding is this agreement has been captured into the TR as part of the evaluation assumptions. No need to consider further.**

**Add ”** Enhancements to ED threshold, contention window sizes etc. can be considered as part of the evaluations.” To Section A.3 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | Only the main line of the agreement is currently captured in Section A.3. The bullet ”Enhancement to ED threshold....” is not mentioned anywhere in TR. We believe that the bullet needs to be captured in A.3 right after the sentence ” LBT procedures in draft v2.1.20 of EN 302 567 as the baseline system evaluation with LBT” or the whole agreement (including the bullet) be mentioned in Section 5 of the TR.  |

# Agreements from RAN1 #103-e

### Agreement #20:

* Numerologies below 120 kHz or above 960 kHz are not supported for any signal or channel.

### Agreement #21:

* For operation in 52-71 GHz:
	+ 120 kHz should be supported
	+ Up to two additional SCS may be considered and at least one should be supported
	+ FFS: Applicability of additional SCS to particular signals and channels

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under 4.1.2.1 Candidate numerology and bandwidth**
	* **In order to minimize specification effort while maximizing supported use cases and deployment scenarios applicable for 52.6 GHz to 71 GHz frequency, It is recommended to support 120 kHz subcarrier spacing with normal CP length, and at least one more subcarrier spacing. It is recommended to consider supporting at most up to three subcarrier spacings, including 120 kHz subcarrier spacing.**
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | It is not clear whether we should continue commenting on the same TP under 8.2.1 or here...? |
| Ericsson | Similar question as Huawei – there is a proposal currently under discussion in 8.2.1 that would seem to replace this |
| Ericsson 2 | It seems these agreements are superceded by Agreement #45 |
| InterDigital | We agree with Ericsson that these agreements are supercede by Agreement #45. |

### Agreement #22:

* At least when operating with LBT, MCOT is 5ms, including all the gaps inside
* Note: Discussions related to further reductions in MCOT due to potential definition of CAPC will be handled separately.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**

**For NR operating with LBT, maximum channel occupancy time (MCOT) duration is 5 msec, including all gaps inside the COT.** Discussions related to further reductions in MCOT due to potential definition of CAPC will be handled separately |
|  **Company** | **Comments** |
| Huawei, HiSilicon | We believe that the ”Note” to the agreement is important and needs to also be captured. We suggest the following:**”For NR operating with LBT, maximum channel occupancy time (MCOT) duration is 5 msec, including all gaps inside the COT.** Discussions related to further reductions in MCOT due to potential definition of CAPC will be handled separately” |
| Moderator | Updated as suggested by Huawei. |
| Huawei/HiSilicon3 | **Please make the following change to accurately reflect Agreement#22. Please also not that the possibility of intorducing MCOT limits for the scenario that LBT is not required is going to be investigated during WI (Please see Agreement#27).****”For NR at least when operating with LBT, maximum channel occupancy time (MCOT) duration is 5 msec, including all gaps inside the COT.** Discussions related to further reductions in MCOT due to potential definition of CAPC will be handled separately” |

### Agreement #25:

* Use the CCA check procedure in EN 302 567 (per RAN1 understanding as from RAN1 #102-e) as the baseline for channel access for 60GHz band when LBT is applied. The following can be discussed further during normative work.
	+ Whether CAPC and contention window adjustment mechanisms are introduced
	+ Whether ED threshold change is needed, e.g., due to changes in bandwidth, beamforming gain etc.
	+ Whether contention window range needs to be adjusted

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.1**
	* **Delete** (per RAN1 understanding as from RAN1 #102-e) **and copy & paste agreement from RAN1 #102-e.**

Use the CCA check procedure in EN 302 567 as the baseline for channel access for 60GHz band when LBT is applied. The following can be discussed further during normative work:- whether CAPC and contention window adjustment mechanisms are introduced,- whether ED threshold change is needed, e.g., due to changes in bandwidth, beamforming gain etc, and- whether contention window range needs to be adjusted. |
|  **Company** | **Comments** |
| LGE | * 5.1 Identification of regulatory aspects for consideration
	+ “(per RAN1 understanding as from RAN1 #102-e)” can be deleted and the following paragraph can be moved to the bottom of the same section.

Use the CCA check procedure in EN 302 567 (per RAN1 understanding as from RAN1 #102-e) as the baseline for channel access for 60GHz band when LBT is applied. The following can be discussed further during normative work:-     whether CAPC and contention window adjustment mechanisms are introduced,-     whether ED threshold change is needed, e.g., due to changes in bandwidth, beamforming gain etc, and-     whether contention window range needs to be adjusted. |
| Moderator | Updated as suggested by LG |

### Agreement #26:

* Capture the following in the TR:
	+ On the LBT bandwidth (bandwidth over which a single contiguous LBT is performed) relative to channel bandwidth (as defined in RAN4), the following alternatives have been discussed. Further down-selection of one or more of these alternatives (if needed) should be further discussed when specifications are developed.
		- Alt 1: LBT bandwidth equals channel bandwidth
		- Alt 2: LBT bandwidth equals the minimum of channel bandwidth and the transmission bandwidth (number of RBs for a given transmission)
		- Alt 3: LBT bandwidth can be wider than channel bandwidth
		- Alt 4: LBT bandwidth can be narrower than the channel bandwidth, with multiple LBT subband within a channel
		- Alt 5: LBT bandwidth equals with minimum supported channel bandwidth or multiples of the minimum supported channel bandwidth

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #27:

* Capture the following in the TR:
	+ For operation where LBT is not required, it can be further discussed when specifications are developed
		- If RAN1 should introduce additional conditions/mechanisms for no-LBT to be used, or leave it for gNB implementation
		- When no-LBT mode is used, if RAN1 should introduce additional restrictions, such as DFS needs to be applied, ATPC needs to be applied, long term sensing needs to be applied, certain duty cycle limitation, certain transmit power limitation, MCOT limits, etc, or leave the restriction for gNB implementation
		- When no-LBT mode is used, if RAN1 should introduce mechanism for the system to fallback to LBT mode, or leave it for gNB implementation

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**
	* For operation where LBT is not required, it can be further discussed when specifications are developed
		+ Whetherto introduce additional conditions and mechanisms for no-LBT to be used, or whether to leave it for gNB implementation.
		+ When no-LBT mode is used, whether to introduce additional restrictions, such as DFS needs to be applied, ATPC needs to be applied, long term sensing needs to be applied, certain duty cycle limitation, certain transmit power limitation, MCOT limits, etc, or leave the restriction for gNB implementation.
		+ When no-LBT mode is used, whether to introduce mechanism for the system to fallback to LBT mode, or whether to leave it for gNB implementation.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #45:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

1. It was observed that amount of specification effort increases with the number of new numerologies enabled and supported for 52.6 GHz to 71 GHz frequency.
2. In order to minimize specification effort while maximizing supported use cases and deployment scenarios applicable for 52.6 GHz to 71 GHz frequency, It is recommended to support 120 kHz subcarrier spacing with normal CP length, and at least one more subcarrier spacing. It is recommended to consider supporting at most up to three subcarrier spacings, including 120 kHz subcarrier spacing. Applicability of the supported subcarrier spacing to particular signals and channels should be further discussed in the corresponding WI phase.
3. It is recommended that numerologies 240 kHz, 480 kHz, and 960 kHz are considered as candidates for additional numerologies in addition to 120 kHz, and numerologies outside this range are not supported for any signals or channels.
4. In order to bound implementation complexity, it is recommended to limit the maximum FFT size required to operate system in 52.6 GHz to 71 GHz frequency to 4096 and to limit the maximum of RBs per carrier to 275 RBs.
5. Selection of the additional subcarrier spacing (on top of 120 kHz) should consider versatility of being able to support various applications and deployment scenarios with all the subcarrier spacings that would be supported by specification, accounting for what is already supported in Rel-15 and Rel-16 specifications.
6. Some companies have noted that ability for a deployed system to operate with a single numerology for all channels and signals is beneficial, and some companies have further noted benefit remains even if SSB numerology is different. Some companies have noted mixed numerology operation is functional and is supported in Rel-15 and Rel-16 specifications (e.g. 240 kHz SSB subcarrier spacing with 120 kHz subcarrier spacing for PDCCH/PDSCH/PUSCH/PUCCH/PRACH in an initial BWP and activation of a dedicated BWP with SCS different than the initial BWP) and consideration of single numerology operation is not needed.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.2.1**

**It was observed that amount of specification effort increases with the number of new numerologies enabled and supported for 52.6 GHz to 71 GHz frequency.****In order to minimize specification effort while maximizing supported use cases and deployment scenarios applicable for 52.6 GHz to 71 GHz frequency, it is recommended to support 120 kHz subcarrier spacing with normal CP length, and at least one more subcarrier spacing. It is recommended to consider supporting at most up to three subcarrier spacings, including 120 kHz subcarrier spacing. Applicability of the supported subcarrier spacing to particular signals and channels should be further discussed in the corresponding WI phase.****It is recommended that numerologies 240 kHz, 480 kHz, and 960 kHz are considered as candidates for additional numerologies in addition to 120 kHz, and numerologies outside this range are not supported for any signals or channels.****In order to bound implementation complexity, it is recommended to limit the maximum FFT size required to operate system in 52.6 GHz to 71 GHz frequency to 4096 and to limit the maximum number of RBs per carrier to 275 RBs.****Selection of the additional subcarrier spacing (on top of 120 kHz) should consider versatility of being able to support various applications and deployment scenarios with all the subcarrier spacings that would be supported by specification, accounting for what is already supported in Rel-15 and Rel-16 specifications.****Some companies have noted that ability for a deployed system to operate with a single numerology for all channels and signals is beneficial, and some companies have further noted benefit remains even if SSB numerology is different. Some companies have noted mixed numerology operation is functional and is supported in Rel-15 and Rel-16 specifications (e.g. 240 kHz SSB subcarrier spacing with 120 kHz subcarrier spacing for PDCCH/PDSCH/PUSCH/PUCCH/PRACH in an initial BWP and activation of a dedicated BWP with SCS different than the initial BWP) and consideration of single numerology operation is not needed.** |
|  **Company** | **Comments** |
| Lenovo, Motorola Mobility | **It was observed that amount of specification effort increases with the number of new numerologies enabled and supported for 52.6 GHz to 71 GHz frequency.****In order to minimize specification effort while maximizing supported use cases and deployment scenarios applicable for 52.6 GHz to 71 GHz frequency, ~~I~~it is recommended to support 120 kHz subcarrier spacing with normal CP length, and at least one more subcarrier spacing. It is recommended to consider supporting at most up to three subcarrier spacings, including 120 kHz subcarrier spacing. Applicability of the supported subcarrier spacing to particular signals and channels should be further discussed in the corresponding WI phase.****It is recommended that numerologies 240 kHz, 480 kHz, and 960 kHz are considered as candidates for additional numerologies in addition to 120 kHz, and numerologies outside this range are not supported for any signals or channels.****In order to bound implementation complexity, it is recommended to limit the maximum FFT size required to operate system in 52.6 GHz to 71 GHz frequency to 4096 and to limit the maximum number of RBs per carrier to 275 RBs.****Selection of the additional subcarrier spacing (on top of 120 kHz) should consider versatility of being able to support various applications and deployment scenarios with all the subcarrier spacings that would be supported by specification, accounting for what is already supported in Rel-15 and Rel-16 specifications.****Some companies have noted that ability for a deployed system to operate with a single numerology for all channels and signals is beneficial, and some companies have further noted benefit remains even if SSB numerology is different. Some companies have noted mixed numerology operation is functional and is supported in Rel-15 and Rel-16 specifications (e.g. 240 kHz SSB subcarrier spacing with 120 kHz subcarrier spacing for PDCCH/PDSCH/PUSCH/PUCCH/PRACH in an initial BWP and activation of a dedicated BWP with SCS different than the initial BWP) and consideration of single numerology operation is not needed.** |
| Moderator | **Updated as suggested by Lenovo/Motorola Mobility** |

### Agreement #46:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

Overall implementation complexity for supporting a specific subcarrier spacing may need to consider the following, but not limited to:

* processing complexity for equalization including inter-carrier interference mitigation (if required to support higher modulation orders) and compensation, andFFT complexity per unit time for a given bandwidth,
* complexity associated with supporting multiple component carriers to reach a specific throughput
* complexity associated with supporting given reduced (in abosolute time) requirements on UE processing times (e.g. N1, N2, N3, Z1, Z2, Z3, etc) and UE PDCCH processing budget as a function of subcarrier spacing, if scheduling and monitoring unit is maintained to be one slot.
* supported features indicated by UE capability signaling or implemented by the gNB
* complexity associated with supporting required timing error tolerance which may need to considerinitial timing error, timing advance setting, TA granularity, MIMO TAE (TAE value will be defined by RAN4), multi-TRP timing alignment as a function of SCS, whether mixture or a single subcarrier spacing for signals is configured, and deployment scenarios.
* complexity associated with supporting higher sampling rates and with channel bandwidth larger than 2 GHz

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.2.1**

Overall implementation complexity for supporting a specific subcarrier spacing may need to consider the following, but not limited to:* processing complexity for equalization including inter-carrier interference mitigation (if required to support higher modulation orders) and compensation, and FFT complexity per unit time for a given bandwidth,
* complexity associated with supporting multiple component carriers to reach a specific throughput
* complexity associated with supporting given reduced (in absolute time) requirements on UE processing times (e.g. N1, N2, N3, Z1, Z2, Z3, etc) and UE PDCCH processing budget as a function of subcarrier spacing, if scheduling and monitoring unit is maintained to be one slot,
* supported features indicated by UE capability signalling or implemented by the gNB,
* complexity associated with supporting required timing error tolerance which may need to consider initial timing error, timing advance setting, TA granularity, MIMO TAE (TAE value will be defined by RAN4), multi-TRP timing alignment as a function of SCS, whether mixture or a single subcarrier spacing for signals is configured, and deployment scenarios,
* complexity associated with supporting higher sampling rates and with channel bandwidth larger than 2 GHz.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #47:

* It is observed that for a single carrier with the same number of transmitted symbols, in general, smaller subcarrier spacing may potentially provide larger coverage due to use of smaller bandwidth and gears towards (but not limited to) coverage driven scenarios.
* It is observed that for a single carrier, in general, larger subcarrier spacing may potentially provide higher peak data rates due to use of larger bandwidth and gears towards (but not limited to) peak data-rate driven scenarios.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.2.1**

**It is observed that for a single carrier with the same number of transmitted symbols, in general, smaller subcarrier spacing may potentially provide larger coverage due to use of smaller bandwidth and gears towards (but not limited to) coverage driven scenarios.****It is observed that for a single carrier, in general, larger subcarrier spacing may potentially provide higher peak data rates due to use of larger bandwidth and gears towards (but not limited to) peak data-rate driven scenarios.** |
|  **Company** | **Comments** |
|  |  |

### Agreement #56:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

1. Some companies noted that standardization effort to support 240 kHz, 480 kHz, and 960 kHz numerologies are comparable. Some companies noted that standardization effort for 240 kHz numerology could be relatively smaller compared to 480 kHz or 960 kHz numerologies.
2. The following, which is not an exhaustive list, are some potential physical layer impact that are common to all numerologies:
	1. supporting unlicensed operation
	2. if mixed numerology is supported, supporting mixed numerology operation.
	3. SSB and CORESET#0 offsets needed for supported channelization
3. The following, which is not an exhaustive list, are some potential physical layer impact areas for each numerology:
	1. 120 kHz:
		1. Potential consideration of PTRS enhancement for CP-OFDM and DFT-s-OFDM, if needed
	2. 240 kHz:
		1. Potential consideration of PTRS enhancement for CP-OFDM and DFT-s-OFDM, if needed
		2. If common SSB/CORESET0 numerology (240/240) is supported, SSB patterns, and CORESET#0 configuration
		3. RO configuration
		4. Timelines for scheduling, processing and HARQ
		5. Potential enhancement to DM-RS, if needed
		6. PDCCH monitoring
	3. 480 kHz:
		1. If 480 kHz SSB is supported, SSB patterns, and CORESET#0 configuration
		2. Timelines for scheduling, processing and HARQ
		3. RO configuration
		4. Potential enhancement to DM-RS, if needed
		5. PDCCH monitoring
		6. Potential consideration of PTRS enhancement for CP-OFDM and DFT-s-OFDM, if neeeded
	4. 960 kHz:
		1. Potential consideration of ECP, if needed, depending on deployment scenarios
		2. If 960 kHz SSB is supported, SSB patterns, and CORESET#0 configuration
		3. Timelines for scheduling, processing and HARQ
		4. RO configuration
		5. Potential enhancement to DM-RS, if needed
		6. PDCCH monitoring
		7. Potential updates to smallest time unit, Tc, used in specifications depending on supported maximum carrier BW

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.3.1**
2. Some companies noted that standardization effort to support 240 kHz, 480 kHz, and 960 kHz numerologies are comparable. Some companies noted that standardization effort for 240 kHz numerology could be relatively smaller compared to 480 kHz or 960 kHz numerologies.
3. The following, which is not an exhaustive list, are some potential physical layer impacts that are common to all numerologies:
	1. supporting unlicensed operation
	2. if mixed numerology is supported, supporting mixed numerology operation.
	3. SSB and CORESET#0 offsets needed for supported channelization
4. The following, which is not an exhaustive list, are some potential physical layer impact areas for each numerology:
	1. For 120 kHz subcarrier spacing:
		1. Potential consideration of PTRS enhancement for CP-OFDM and DFT-s-OFDM, if needed.
	2. For 240 kHz subcarrier spacing:
		1. Potential consideration of PTRS enhancement for CP-OFDM and DFT-s-OFDM, if needed,
		2. If common SSB/CORESET#0 numerology (240/240) is supported, SSB patterns, and CORESET#0 configuration,
		3. RO configuration,
		4. Timelines for scheduling, processing and HARQ,
		5. Potential enhancement to DM-RS, if needed,
		6. PDCCH monitoring.
	3. For 480 kHz subcarrier spacing:
		1. If 480 kHz SSB is supported, SSB patterns, and CORESET#0 configuration,
		2. Timelines for scheduling, processing and HARQ,
		3. RO configuration,
		4. Potential enhancement to DM-RS, if needed,
		5. PDCCH monitoring,
		6. Potential consideration of PTRS enhancement for CP-OFDM and DFT-s-OFDM, if needed.
	4. For 960 kHz subcarrier spacing:
		1. Potential consideration of ECP, if needed, depending on deployment scenarios ,
		2. If 960 kHz SSB is supported, SSB patterns, and CORESET#0 configuration,
		3. Timelines for scheduling, processing and HARQ,
		4. RO configuration,
		5. Potential enhancement to DM-RS, if needed,
		6. PDCCH monitoring,
		7. Potential updates to smallest time unit, Tc, used in specifications depending on supported maximum carrier BW.
 |
|  **Company** | **Comments** |
| Lenovo, Motorola Mobility | Editorial update below:1. The following, which is not an exhaustive list, are some potential physical layer impact**s** that are common to all numerologies:
 |
| LGE | * 4.1.3.1 General physical layer impacts
	+ “#” is missing

If common SSB/CORESET#0 numerology (240/240) is supported, SSB patterns, and CORESET#0 configuration, |
| Moderator | Updated as suggested by Lenovo |

### Agreement #57:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

Observations on the delay spread distribution:

1. One source (R1-2007654, vivo) observed that for the delay spread distributions for the typical indoor scenarios evaluated, the delay spread of almost 80% of the users are less than 30 nsec.
2. One source (R1-2007982, Ericsson) observed that Factory Scenario A (InF-DH) results in post-beamforming delay spreads that are a significant fraction of the CP duration for 960 kHz SCS.
3. One source (R1-2007943, Intel) observed that 85% of the UE experience r.m.s delay spread small than CP length of 1.92 MHz subcarrier spacing (i.e. 36.6ns) in indoor, outdoor, and factory scenarios.
4. One source (R1-2008615, Qualcomm) observed that for small range indoor hotspot deployment, the channel delay spread is not an issue with normal CP. For outdoor scenarios with larger ISD and at moderate to high SNR (this may be produced by higher EIRP or smaller BW), normal CP demonstrates SINR degradation compared to extended CP. However, for such large coverage, high EIRP, and small BW use cases, we can choose to use a small SCS, e.g., 120kHz, with NCP.
5. One source (R1-2007790, Interdigital) observed that while each scenario experiences different amounts of r.m.s. delay spread, regardless of scenarios, most of UEs experience smaller r.m.s. delay spreads than normal CP of 960 kHz.
6. One source (R1-2009062, Docomo) observed that the mean r.m.s. delay spread of 60 GHz system in Outdoor-B scenario is about 23 nsec and the 95%-tile delay spread value is about 80 nsec. More than half of UE experiences channels with delay larger than 20 ns, which should be referred to in the link performance evaluation with large delay configurations.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 6.3**

The following are observations on the delay spread distribution**:*** **One source [60] observed that for the delay spread distributions for the typical indoor scenarios evaluated, the delay spread of almost 80% of the users are less than 30 nsec.**
* **One source [18] observed that Factory Scenario A (InF-DH) results in post-beamforming delay spreads that are a significant fraction of the CP duration for 960 kHz SCS.**
* **One source [63] observed that 85% of the UE experience r.m.s delay spread small than CP length of 1.92 MHz subcarrier spacing (i.e. 36.6ns) in indoor, outdoor, and factory scenarios.**
* **One source [30] observed that for small range indoor hotspot deployment, the channel delay spread is not an issue with normal CP. For outdoor scenarios with larger ISD and at moderate to high SNR (this may be produced by higher EIRP or smaller BW), normal CP demonstrates SINR degradation compared to extended CP. However, for such large coverage, high EIRP, and small BW use cases, we can choose to use a small SCS, e.g., 120kHz, with NCP.**
* **One source [38] observed that while each scenario experiences different amounts of r.m.s. delay spread, regardless of scenarios, most of UEs experience smaller r.m.s. delay spreads than normal CP of 960 kHz.**
* **One source [29] observed that the mean r.m.s. delay spread of 60 GHz system in Outdoor-B scenario is about 23 nsec and the 95%-tile delay spread value is about 80 nsec. More than half of UE experiences channels with delay larger than 20 ns, which should be referred to in the link performance evaluation with large delay configurations.**
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #58:

Capture the following observations in the TR (Editorial modifications and changes to references can be made when capturing the observations in the TR):

1. Some companies have noted support of channelization that are aligned with IEEE 802.11ad and 802.11ay channelization is beneficial for coexistence. While some companies have noted alignment of channelization for coexistence is not necessary. Alignment of channelization between a NR channel and IEEE 802.11ad and 802.11ay channel in this context refers to a NR channel that is contained within one of the channels defined for IEEE 802.11ad and 802.11ay and NR channel bandwidth does not cross over channel boundaries of IEEE 802.11ad and 802.11ay.
2. One company has evaluated misaligned NR wideband channels with 1.6 GHz and 2 GHz without LBT and have not identified coexistence issues between NR and NR.
3. Some companies proposed that 2 GHz channel bandwidth should be supported andhave the raster points for 2 GHz channel bandwidth to be aligned with IEEE 802.11ad and 802.11ay channelization.
4. Some companies proposed that 1.6 GHz should be the maximum channel bandwidth and channels do not necessarily need to be aligned with IEEE 802.11ad and 802.11ay channelizations.
5. Some companies observed that support of channel bandwidth such as 200 or 400 MHz may enable efficient usage of available spectrum by 3GPP technology. Some companies observed that only supporting channelization that are alignemed with IEEE 802.11ad and 802.11ay channelization result in smaller number of supported channels for some regions of the world.
6. Some companies have observed that channelization based on granularity of minimum supported channel BW would be benefitial and could provide efficient usage of available specturm. Other companies have observerd that support of channel BW such as 1.6 GHz or 2.4GHz would enable efficient usage of 5 GHz allocation in China and 5 GHz IMT allocation in Europe. Some companies have observed that smaller bandwidth (e.g. 1.6 GHz) allows for more channels (e.g., with 1.6 GHz, 3 channels instead of two) in these regions, easing frequency planning between operators at the cost of reduction in available channel bandwidth per carrier.
7. Some companies proposed to support more than one channel bandwidths for a given SCS.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.2.2**

**Some companies have noted support of channelization that are aligned with IEEE 802.11ad and 802.11ay channelization is beneficial for coexistence. While some companies have noted alignment of channelization for coexistence is not necessary. Alignment of channelization between a NR channel and IEEE 802.11ad and 802.11ay channel in this context refers to a NR channel that is contained within one of the channels defined for IEEE 802.11ad and 802.11ay and NR channel bandwidth does not cross over channel boundaries of IEEE 802.11ad and 802.11ay.** **One company has evaluated misaligned NR wideband channels with 1.6 GHz and 2 GHz without LBT and have not identified coexistence issues between NR and NR.****Some companies proposed that 2 GHz channel bandwidth should be supported and have the raster points for 2 GHz channel bandwidth to be aligned with IEEE 802.11ad and 802.11ay channelization.** **Some companies proposed that 1.6 GHz should be the maximum channel bandwidth and channels do not necessarily need to be aligned with IEEE 802.11ad and 802.11ay channelizations.****Some companies observed that support of channel bandwidth such as 200 or 400 MHz may enable efficient usage of available spectrum by 3GPP technology. Some companies observed that only supporting channelization that are aligned with IEEE 802.11ad and 802.11ay channelization result in smaller number of supported channels for some regions of the world.****Some companies have observed that channelization based on granularity of minimum supported channel BW would be beneficial and could provide efficient usage of available spectrum. Other companies have observed that support of channel BW such as 1.6 GHz or 2.4GHz would enable efficient usage of 5 GHz allocation in China and 5 GHz IMT allocation in Europe. Some companies have observed that smaller bandwidth (e.g. 1.6 GHz) allows for more channels (e.g., with 1.6 GHz, 3 channels instead of two) in these regions, easing frequency planning between operators at the cost of reduction in available channel bandwidth per carrier.****Some companies proposed to support more than one channel bandwidths for a given SCS.** |
|  **Company** | **Comments** |
|  |  |

### Agreement #59:

Capture the following observations in the TR (Editorial modifications and changes to references can be made when capturing the observations in the TR):

1. Some companies noted SSB SCS selection should consider SCS of data/control channels and enablement of single subcarrier spacing operation.
2. Some companies noted support and use of 120 kHz and/or 240 kHz SCS for SSB and 120 kHz subcarrier spacing for CORESET#0 in initial BWP and activation of dedicated BWP with an SCS for data/control different than the initial BWP may enable re-use of existing NR specification and minimize standardization effort.
3. It was identified to further investigate considerations of SSB patterns, if needed, considering:
	1. unlicensed band operation if LBT is required for SSB, e.g. SSB cycling transmission within a DRS transmission window.
	2. Beam switching time between SSB,
	3. Coverage of SSB
	4. Multiplexing of SSB with CORESET and UL transmissions

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.3.2**
* Some companies noted SSB SCS selection should consider SCS of data/control channels and enablement of single subcarrier spacing operation.
* Some companies noted support and use of 120 kHz and/or 240 kHz SCS for SSB and 120 kHz subcarrier spacing for CORESET#0 in initial BWP and activation of dedicated BWP with an SCS for data/control different than the initial BWP may enable re-use of existing NR specification and minimize standardization effort.
* It was identified to further investigate considerations of SSB patterns, if needed, considering:
	+ unlicensed band operation if LBT is required for SSB, e.g. SSB cycling transmission within a DRS transmission window,
	+ beam switching time between SSB,
	+ coverage of SSB,
	+ multiplexing of SSB with CORESET and UL transmissions.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #60:

Capture the following observations in the TR (Editorial modifications and changes to references can be made when capturing the observations in the TR):

1. In order to benefit from higher transmit power, when maximum PSD regulatory requirements exist, RAN1 recommends support of longer PRACH sequence lengths, L=571 and L=1151, defined in Rel-16 NR specification, to be used for NR operating in 52.6 GHz to 71 GHz.
2. It is recommended to not support interlace design for PRACH for NR operating in 52.6 GHz to 71 GHz.
3. It is recommended to further investigate whether or not to support configurations that enable non-consecutive RACH occasions in time domainto aid LBT processes if LBT is required.
4. Some companies noted that PRACH SCS selection should consider SCS of data/control channels and enablement of single subcarrier spacing operation.
5. Some companies noted that 120 kHz SCS for PRACH (even if data/control channel may have different SCS) may be sufficient to support NR operating in 52.6 GHz to 71 GHz from coverage perspective.
6. It was identified that potential enhancements for PRACH should consider system coverage for PRACH with subcarrier spacing larger than 120 kHz, if supported.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.3.2**

**In order to benefit from higher transmit power, when maximum PSD regulatory requirements exist, RAN1 recommends support of longer PRACH sequence lengths, L=571 and L=1151, defined in Rel-16 NR specification, to be used for NR operating in 52.6 GHz to 71 GHz.****It is recommended to not support interlace design for PRACH for NR operating in 52.6 GHz to 71 GHz.****It is recommended to further investigate whether or not to support configurations that enable non-consecutive RACH occasions in time domain to aid LBT processes if LBT is required.****Some companies noted that PRACH SCS selection should consider SCS of data/control channels and enablement of single subcarrier spacing operation.****Some companies noted that 120 kHz SCS for PRACH (even if data/control channel may have different SCS) may be sufficient to support NR operating in 52.6 GHz to 71 GHz from coverage perspective.****It was identified that potential enhancements for PRACH should consider system coverage for PRACH with subcarrier spacing larger than 120 kHz, if supported.** |
|  **Company** | **Comments** |
|  |  |

### Agreement #61:

Capture the following observations in the TR (Editorial modifications and changes to references can be made when capturing the observations in the TR):

1. It was identified that the potential enhancements to PDCCH monitoring including potential limitation to UE PDCCH configuration,, multiple PDSCH/PUSCH scheduling with a single DCI (using existing DCI formats or new DCI format(s)), spatial relation management for GC-PDCCH, capability related to PDCCH monitoring, and PDCCH coverage should be further investigated for higher subcarrier spacings, including the need for such enhancements.
2. It was observed that PDCCH processing capabilities per multiple slots for larger SCS (e.g. 480 or 960 kHz) can maintain scheduling framework same as for smaller SCS (e.g. 120 kHz) when the UE is configured to monitor the PDCCH every multiple slots.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.3.4**

**It was identified that the potential enhancements to PDCCH monitoring including potential limitation to UE PDCCH configuration, multiple PDSCH/PUSCH scheduling with a single DCI (using existing DCI formats or new DCI format(s)), spatial relation management for GC-PDCCH, capability related to PDCCH monitoring, and PDCCH coverage should be further investigated for higher subcarrier spacings, including the need for such enhancements.****It was observed that PDCCH processing capabilities per multiple slots for larger SCS (e.g. 480 or 960 kHz) can maintain scheduling framework same as for smaller SCS (e.g. 120 kHz) when the UE is configured to monitor the PDCCH every multiple slot.** |
|  **Company** | **Comments** |
| Lenovo, Motorola Mobility | Editorial update:**It was identified that the potential enhancements to PDCCH monitoring including potential limitation to UE PDCCH configuration,~~,~~ multiple PDSCH/PUSCH scheduling with a single DCI (using existing DCI formats or new DCI format(s)), spatial relation management for GC-PDCCH, capability related to PDCCH monitoring, and PDCCH coverage should be further investigated for higher subcarrier spacings, including the need for such enhancements.** |
| Moderator | Updated as suggested by Lenovo. |

### Agreement #62:

Capture the following observations in the TR (Editorial modifications and changes to references can be made when capturing the observations in the TR):

1. Some companies have noted that interlace transmissions for PUSCH do not provide benefit over non-interlaced uplink allocations currently supported by NR for NR operating in 52.6 GHz to 71 GHz, while some companies have noted support of sub-PRB or PRB interlace transmissions for PUSCH may improve transmit power and possibly meets OCB requirements (some companies note OCB requirements can be met without introducing interlacing) when necessary.
2. It was identified that for new subcarrier spacing, if agreed, will at least require investigation on the need for enhacnments and standardization, of the following processing timelines:
	1. Processing capability for PUSCH scheduled by RAR UL grant
	2. Dynamic SFI and SPS/CG cancellation timing
	3. Timeline for HARQ-ACK information in response to a SPS PDSCH release/dormancy.
	4. Minimum time gap for wake-up and Scell dormancy indication (DCI format 2\_6)
	5. BWP switch delay
	6. Multi-beam operation timing (timeDurationForQCL, beamSwitchTiming, beam switch gap, beamReportTiming, etc.)
	7. Timeline for multiplexing multiple UCI types
	8. Minimum of P\_switch for search space set group switching
	9. appropriate configuration(s) of k0 (PDSCH), k1 (HARQ), k2 (PUSCH),
	10. PDSCH processing time (N1), PUSCH preparation time (N2), HARQ-ACK multiplexing timeline (N3)
	11. CSI processing time, Z1, Z2, and Z3, and CSI processing units
	12. Any potential enhancements to CPU occupation calculation
	13. Related UE capability(ies) for processing timelines
	14. minimum guard period between two SRS resources of an SRS resource set for antenna switching
3. It was identified that new subcarrier spacing, if agreed, may require further investigation of multi-PDSCH/PUSCH scheduling and standardization, if needed. The following aspects should be at least investigated for multi-PDSCH/PUSCH scheduling:
	1. whether to support a single TB and/or multiple TBs scheduled over multiple slots
	2. applicable DCI format(s) (including potential new formats, if needed) for multi-PDSCH and multi-PUSCH scheduling
	3. Enhancement on multiple beam indication and association with multiple PDSCH/PUSCH scheduling
	4. DM-RS enhancements such as DM-RS bundling, or changes to the time-domain pattern
	5. HARQ enhancements for multi-PDSCH
	6. Applicability of Rel-16 multi-PUSCH scheduling

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.3.3**
* Some companies have noted that interlace transmissions for PUSCH do not provide benefit over non-interlaced uplink allocations currently supported by NR for NR operating in 52.6 GHz to 71 GHz, while some companies have noted support of sub-PRB or PRB interlace transmissions for PUSCH may improve transmit power and possibly meets OCB requirements (some companies note OCB requirements can be met without introducing interlacing) when necessary.
* It was identified that new subcarrier spacing, if agreed, may require further investigation of multi-PDSCH/PUSCH scheduling and standardization, if needed. The following aspects should be at least investigated for multi-PDSCH/PUSCH scheduling:
	+ whether to support a single TB and/or multiple TBs scheduled over multiple slots,
	+ applicable DCI format(s) (including potential new formats, if needed) for multi-PDSCH and multi-PUSCH scheduling,
	+ enhancement on multiple beam indication and association with multiple PDSCH/PUSCH scheduling,
	+ DM-RS enhancements such as DM-RS bundling, or changes to the time-domain pattern,
	+ HARQ enhancements for multi-PDSCH,
	+ applicability of Rel-16 multi-PUSCH scheduling.
1. **Capture under Section 4.1.3.1**
* It was identified that for new subcarrier spacing, if agreed, will at least require investigation on the need for enhancements and standardization, of the following processing timelines:
	+ processing capability for PUSCH scheduled by RAR UL grant,
	+ dynamic SFI and SPS/CG cancellation timing,
	+ timeline for HARQ-ACK information in response to a SPS PDSCH release/dormancy,
	+ minimum time gap for wake-up and Scell dormancy indication (DCI format 2\_6),
	+ BWP switch delay,
	+ multi-beam operation timing (timeDurationForQCL, beamSwitchTiming, beam switch gap, beamReportTiming, etc.),
	+ timeline for multiplexing multiple UCI types,
	+ minimum of P\_switch for search space set group switching,
	+ appropriate configuration(s) of k0 (PDSCH), k1 (HARQ), k2 (PUSCH),
	+ PDSCH processing time (N1), PUSCH preparation time (N2), HARQ-ACK multiplexing timeline (N3),
	+ CSI processing time, Z1, Z2, and Z3, and CSI processing units,
	+ any potential enhancements to CPU occupation calculation,
	+ related UE capability(ies) for processing timelines,
	+ minimum guard period between two SRS resources of an SRS resource set for antenna switching.
 |
|  **Company** | **Comments** |
| Huawei | In section 4.1.3.3, the first paragraph seems to answer the “further study” from the second paragraph. Is the second paragraph still needed? The next paragraph with generic bullet points on processing time seems to fit better under 4.1.3.1, as not all points are specific to PDSCH/PUSCH?Moderator note: Huawei generic bullet points are referring to the 2nd bullet of the agreement. |
| Moderator | Moved the 2nd bullet to 4.1.3.1 as suggested. |

### Agreement #63:

Capture the following observations in the TR (Editorial modifications and changes to references can be made when capturing the observations in the TR):

It is recommended to further investigate potential enhancements to PUCCH to enable higher transmission power when regulatory limits apply. Further potential enhancements to spatial relation management for configured and/or semi-persistent UL signals/channels may be considered.

1. Majority of the sources have identified PUCCH format 0, 1, and 4 as potential candidates for enahancement.
2. Two sources has identified all PUCCH formats as potential candidates for enhancement.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 4.1.3.5**

It is recommended to further investigate potential enhancements to PUCCH to enable higher transmission power when regulatory limits apply. 1. Majority of the sources have identified PUCCH format 0, 1, and 4 as potential candidates for enhancement.
2. Two sources have identified all PUCCH formats as potential candidates for enhancement.

Further potential enhancements to spatial relation management for configured and/or semi-persistent UL signals/channels may be considered. |
|  **Company** | **Comments** |
| LGE | * 4.1.3.5 Physical layer impacts to PUCCH
	+ It would be better to move the second sentence to the end of paragraph.

It is recommended to further investigate potential enhancements to PUCCH to enable higher transmission power when regulatory limits apply. ~~Further potential enhancements to spatial relation management for configured and/or semi-persistent UL signals/channels may be considered.~~ Majority of the sources have identified PUCCH format 0, 1, and 4 as potential candidates for enhancement. Two sources have identified all PUCCH formats as potential candidates for enhancement. Further potential enhancements to spatial relation management for configured and/or semi-persistent UL signals/channels may be considered. |
| Moderator | Updated as suggested by LG. |

### Agreement #64:

When LBT mode is used, it can be further discussed when specifications are developed if a responding device should use a Cat 2 LBT to share the COT, and if yes, how to define the Cat 2 LBT and if a maximum gap is to be introduced between the initiating device and responding device transmissions.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**

When LBT mode is used, it can be further discussed when specifications are developed if a responding device should use a Cat 2 LBT to share the COT, and if yes, how to define the Cat 2 LBT and if a maximum gap is to be introduced between the initiating device and responding device transmissions. |
|  **Company** | **Comments** |
|  |  |

### Agreement #65:

* Support of contention-exempt short control signalling transmission in 60GHz band for regions where LBT is required and short control signaling without LBT is allowed.
	+ Note: If regulations do not allow short control signaling exemption in a region when operating with LBT, operation with LBT for these short control signals should be supported
* Restrictions to the transmission, such as, on duty cycle (airtime measured over a relatively long period of time), content, TX power, etc. can be discussed when specifications are developed.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**

Support of contention-exempt short control signalling transmission in 60GHz band for regions where LBT is required and short control signaling without LBT is allowed. It should be noted that if regulations do not allow short control signaling exemption in a region when operating with LBT, operation with LBT for these short control signals should be supported. Restrictions to the transmission, such as, on duty cycle (airtime measured over a relatively long period of time), content, TX power, etc. can be discussed when specifications are developed. |
|  **Company** | **Comments** |
| LGE | * 5.2.1 Listen before talk (LBT) design
	+ Typo

Support of contention-exempt short control signalling transmission in 60GHz band for regions where LBT is required and short control signaling without LBT is allowed. It should be noted that ~~Note: I~~if regulations do not allow short control signaling exemption in a region when operating with LBT, operation with LBT for these short control signals should be supported. Restrictions to the transmission, such as, on duty cycle (airtime measured over a relatively long period of time), content, TX power, etc. can be discussed when specifications are developed. |
| Moderator | Corrected the typo. |
| Huawei/HiSilicon3 | The first sentence does not read well as it does not have the main verb. The easiest way to fix this is to remove ”of” after ”Support”. Also, we have noticed that the removed ”Note: If” is still in the Draft TR that shoud be removed. We suggest the following change:Support ~~of~~ contention-exempt short control signalling transmission in 60GHz band for regions where LBT is required and short control signaling without LBT is allowed. It should be noted that if regulations do not allow short control signaling exemption in a region when operating with LBT, operation with LBT for these short control signals should be supported. Restrictions to the transmission, such as, on duty cycle (airtime measured over a relatively long period of time), content, TX power, etc. can be discussed when specifications are developed. |

### Agreement #66:

It can be further discussed when specifications are developed if 3GPP specifications should define the relationship between the LBT beam and the transmission beam or leave it as implementation. If such relationship is defined, it can also be further discussed when specifications are developed if ED threshold should be adjusted by the choice of LBT beam and transmission beam.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**

It can be further discussed when specifications are developed if 3GPP specifications should define the relationship between the LBT beam and the transmission beam or leave it as implementation. If such relationship is defined, it can also be further discussed when specifications are developed if ED threshold should be adjusted by the choice of LBT beam and transmission beam. |
|  **Company** | **Comments** |
|  |  |

### Agreement #67:

When LBT mode is used, spatial domain multiplexing of different beams is supported. The LBT requirement (if any) for spatial domain multiplexing of multiple beams can be further discussed when specifications are developed. At least the following can be considered while other LBT considerations are not excluded.

* Leave the LBT behaviour for implementation
* One LBT beam covers all transmission beams
* Multiple LBT beams cover multiple transmission beams

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**

When LBT mode is used, spatial domain multiplexing of different beams is supported. The LBT requirement (if any) for spatial domain multiplexing of multiple beams can be further discussed when specifications are developed. At least the following can be considered while other LBT considerations are not excluded.* leave the LBT behaviour for implementation,
* one LBT beam covers all transmission beams,
* multiple LBT beams cover multiple transmission beams.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #68:

When LBT mode is used, time domain multiplexing of DL/UL transmissions in different beams in the same COT is supported. The LBT requirement (if any) for time domain multiplexing of DL/UL transmissions in multiple beams can be further discussed when specifications are developed. At least the following can be considered while other LBT considerations are not excluded

* No additional LBT requirement defined and leave the LBT behaviour for implementation
* Perform directional or omni-directional LBT at the beginning of COT with sensing beam(s) that covers all TDM beams and with no LBT before each beam switching in the middle of COT.
* Perform directional or omni-directional LBT at the beginning of COT with sensing beam(s) that covers all TDM beams or the first transmission beam, and additional directional LBT with sensing beam that covers the next transmission beam for each beam switching in the middle of COT.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.1**

When LBT mode is used, time domain multiplexing of DL/UL transmissions in different beams in the same COT is supported. The LBT requirement (if any) for time domain multiplexing of DL/UL transmissions in multiple beams can be further discussed when specifications are developed. At least the following can be considered while other LBT considerations are not excluded:* No additional LBT requirement defined and leave the LBT behaviour for implementation,
* Perform directional or omni-directional LBT at the beginning of COT with sensing beam(s) that covers all TDM beams and with no LBT before each beam switching in the middle of COT,
* Perform directional or omni-directional LBT at the beginning of COT with sensing beam(s) that covers all TDM beams or the first transmission beam, and additional directional LBT with sensing beam that covers the next transmission beam for each beam switching in the middle of COT.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #69:

Capture the following in TR:

The following receiver assisted channel access and interference management schemes have been considered and can be further investigated when specifications are developed

* Class A. Receiver provides assistance information (signalling) to transmitter only. The following aspects of Class A can be further discussed when specifications are developed
	+ Applicability in the following potential channel access modes:
		- LBT is performed prior to transmission
		- No LBT is performed prior to transmission
	+ Details of assistance information (e.g., type, timing, content, how the assistance information is obtained etc.)
	+ Whether the assistance information can be obtained by LBT performed at the receiver prior to transmission
	+ Whether the assistance information can be obtained by existing layer 1 and layer 3 measurements with enhancements if needed
	+ If any specification changes are needed to support Class A

Also, the following receiver assisted channel access schemes have been considered, and considering the system performance and complexity tradeoff, these schemes will not be further investigated in Rel.17

* Class B. Receiver provides assistance information (signalling) to other NR nodes, including non-serving nodes
	+ In this case, cross RAT coexistence is based on ED
	+ Class B1. Intra-operator only
	+ Class B2. Also including inter-operator signalling
		- In this case, cross operator coexistence is based on ED
* Class C. Receiver provides assistance information (signalling) to other NR nodes and nodes from other RAT

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 5.2.3**

The following receiver assisted channel access and interference management schemes have been considered and can be further investigated when specifications are developed.* Class A. Receiver provides assistance information (signalling) to transmitter only. The following aspects of Class A can be further discussed when specifications are developed
	+ Applicability in the following potential channel access modes:
		- LBT is performed prior to transmission
		- No LBT is performed prior to transmission
	+ Details of assistance information (e.g., type, timing, content, how the assistance information is obtained etc.)
	+ Whether the assistance information can be obtained by LBT performed at the receiver prior to transmission
	+ Whether the assistance information can be obtained by existing layer 1 and layer 3 measurements with enhancements if needed
	+ If any specification changes are needed to support Class A

Also, the following receiver assisted channel access schemes have been considered, and considering the system performance and complexity tradeoff, these schemes will not be further investigated in Rel.17* Class B. Receiver provides assistance information (signalling) to other NR nodes, including non-serving nodes
	+ In this case, cross RAT coexistence is based on ED
	+ Class B1. Intra-operator only
	+ Class B2. Also including inter-operator signalling
		- In this case, cross operator coexistence is based on ED
* Class C. Receiver provides assistance information (signalling) to other NR nodes and nodes from other RAT
 |
|  **Company** | **Comments** |
| Ericsson 2 | Fine with the proposal. However, the 5.2.3 section title needs update to reflect ” receiver assisted channel access and interference management” instead of ” Receiver assisted LBT techniques”.  |
| Moderator | Updated as suggested |

# Capturing Evaluation Results and Agreement on Evaluations from RAN1 #103-e

### Agreement #23:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

* Comparison of No-LBT (NLBT) and Tx Side ED based Omnidirectional Sensing (TxED-Omni) for Indoor Scenerio A: 6 Companies have compared No-LBT with Tx Side ED based Omni sensing LBT
	+ Vivo, show tail and median benefits of using TxED-Omni LBT on DL, at high loading. In other cases, including all loads for UL and other loads for DL, TdxED-Omni LBT scheme shows losses. All results are at ED threshold -47.
	+ Intel shows gains for 5%ile DL throughput at high loads with TxED-Omni LBT. In other cases including all loads for UL and other loads for DL, TdxED-Omni LBT scheme shows losses. All results are at ED threshold -47.
	+ Ericsson, HW, Nokia, Qualcomm and Samsung show loss for TxED-Omni LBT with an EDT of -47 or -48 dB for all cases.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture under Section 6.2.2**
* For comparison of No-LBT (NLBT) and Tx Side ED based Omnidirectional Sensing (TxED-Omni) for Indoor Scenerio A, 6 companies have compared No-LBT with TxED-Omni LBT and provide the following observations:
	+ Source [37], show tail and median benefits of using TxED-Omni LBT on DL, at high loading. In other cases, including all loads for UL and other loads for DL, TxED-Omni LBT scheme shows losses. All results are at ED threshold -47 dBm.
	+ Source [16] shows gains for 5%ile DL throughput at high loads with TxED-Omni LBT. In other cases, including all loads for UL and other loads for DL, TxED-Omni LBT scheme shows losses. All results are at ED threshold -47 dBm.
	+ Source [65], [35], [42], [56] and [67] show loss for TxED-Omni LBT with an EDT of -47 dBm or -48 dBm for all cases.
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | Suggest the following editorial modifications:* Comparison of No-LBT (NLBT) and Tx Side ED based Omnidirectional Sensing (TxED-Omni) for Indoor Scenerio A: 6 Companies have compared No-LBT with TxED-Omni LBT
	+ Vivo, show tail and median benefits of using TxED-Omni LBT on DL, at high loading. In other cases, including all loads for UL and other loads for DL, TdxED-Omni LBT scheme shows losses. All results are at ED threshold -47 dBm.
	+ Intel shows gains for 5%ile DL throughput at high loads with TxED-Omni LBT. In other cases including all loads for UL and other loads for DL, TdxED-Omni LBT scheme shows losses. All results are at ED threshold -47 dBm.
	+ Ericsson, HW, Nokia, Qualcomm and Samsung show loss for TxED-Omni LBT with an EDT of -47 dBm or -48 dBm for all cases.
 |

### Agreement #24:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

7 sources ([61, Ericsson], [26, Qualcomm], [56, vivo], [64, OPPO], [21, Apple], [25, NTT DOCOMO], [12, Intel]) reported evaluation results of PSS/SSS detection performance in terms of SINR in dB achieving cell ID detection probability of 90% by one-shot detection from PSS/SSS. 4 sources ([61, Ericsson], [26, Qualcomm], [56, vivo], [21, Apple]) reported PBCH performance in terms of SINR in dB achieving PBCH BLER target of 10%. 2 sources ([5, vivo], [14, 61, Ericsson]) compared link budget of SSB for difference SCS.

* For PSS and SSS detection performance, all evaluated candidate SCSs (120, 240, 480 and 960 kHz) show comparable performances with the non-optional (non-optional to be replaced by references to channel model in Tables to be added when capturing in TR) channel models and delay spread values.
	+ The performance degrades as the increase of SCS.
	+ Note: the following is reference when derive the observations.
	+ 6 out of 7 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 kHz). The other source ([21, Apple]) reported more than 3 dB performance gap of 960 kHz SCS compared to other 120, 240 and 480 kHz SCS. It also reported that the gap of 960 kHz increases as the delay spread increases.
* For PBCH BLER performance, all evaluated candidate SCSs (120, 240, 480 and 960 KHz) show comparable performances with the non-optional (non-optional to be replaced by references to channel model in Tables to be added when capturing in TR) channel models and delay spread.
	+ The performance degrades as the increase of SCS.
	+ All 4 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 KHz).
	+ The performance gap between 120 and 960 kHz is up to ~ 1.8 dB.
* In terms of SSB link budget, smaller SCS have better coverage than larger SCS
	+ The MCL and MIL difference between 120 kHz SCS and 480 kHz SCS is about 5 dB. The MCL and MIL difference between 120 kHz SCS and 960 KHz SCS is about 8 dB.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.2**

7 sources , [65], [30], [60], [68], [25], [29], and [16], reported evaluation results of PSS/SSS detection performance in terms of SINR in dB achieving cell ID detection probability of 90% by one-shot detection from PSS/SSS. 4 sources [65], [30], [60], and [25], reported PBCH performance in terms of SINR in dB achieving PBCH BLER target of 10%. 2 sources , [9], and [65],compared link budget of SSB for difference SCS. For PSS and SSS detection performance, all evaluated candidate SCSs (120, 240, 480 and 960 kHz) show comparable performances with the channel models and delay spread values parameters provided in Table A.1-1.* .The performance degrades as the increase of SCS.
* 6 out of 7 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 kHz). The other source [25] reported more than 3 dB performance gap of 960 kHz SCS compared to other 120, 240 and 480 kHz SCS. It also reported that the gap of 960 kHz increases as the delay spread increases.

For PBCH BLER performance, all evaluated candidate SCSs (120, 240, 480 and 960 kHz) show comparable performances with the channel models and delay spread parameters provided in Table A.1-1.* The performance degrades as the increase of SCS.
* All 4 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 kHz).
* The performance gap between 120 and 960 kHz is up to ~ 1.8 dB.

In terms of SSB link budget, smaller SCS have better coverage than larger SCS * The MCL and MIL difference between 120 kHz SCS and 480 kHz SCS is about 5 dB. The MCL and MIL difference between 120 kHz SCS and 960 kHz SCS is about 8 dB.
 |
|  **Company** | **Comments** |
| Huawei, HiSilicon | Agree observations from performance evaluations should be directly captured as in the agreement. |
| Ericsson | Agree to capture "as is" |
|  |  |

### Agreement #28:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

8 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [25, NTT DOCOMO], [12, Intel]) reported evaluation results of PRACH preamble detection performance in terms of SINR in dB achieving PRACH preamble misdetection probability of 1% with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808. Two sources ([14, 61, Ericsson], [19, OPPO]) compared link budget of PRACH for different SCS.

The following are observed.

* For PRACH preamble detection performances for the same PRACH format, all evaluated candidate SCSs (120, 240, 480 and 960 kHz) show comparable performances
	+ Note: The following references were used to derive the observations.
	+ 7 out of 8 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 kHz). The other source ([64, OPPO]) reported minor performances difference among all SCS for TDL-A with 5 and 10ns DS. It reported infinite SINR for 960 kHz SCS and comparable SINR for 120, 240 and 480 kHz SCS in TDL-A with 20ns DS using the metrics of preamble miss detection probability of 1% and the estimated timing error is within [-Tcp/2, Tcp/2].
* For PRACH link budget of the same PRACH format and the same sequence length, maximum isotropic loss (MIL) and maximum coupling loss (MCL) degrade as the subcarrier spacing is increased, negatively impacting coverage.
	+ Two sources ([14, 61, Ericsson], [19, OPPO]) reported that with UE power limitation of 25 dBm EIRP, the MCL/MIL difference between 120 KHz SCS and 480 KHz SCS is about 4 to 5 dB; the MCL/MIL difference between 120 KHz SCS and 960 KHz SCS is about 8 dB.
	+ One source ([14, 61, Ericsson]) reported that without UE power limitation of 25 dBm EIRP (but still under regulatory limits), the MCL difference between 120 kHz SCS and 480 kHz SCS is less than 2.5 dB; the MCL difference between 120 kHz SCS and 960 kHz SCS is less than 1 dB.
	+ One source ([14, 61, Ericsson]) reported that without UE power limitation of 25 dBm EIRPs (but still under regulatory limits), compared to short PRACH sequence length, longer PRACH sequence length improve MCL/MIL significantly for 120 kHz SCS due to wider bandwidth for a given SCS.

### Agreement #55 (replace #28):

Summary observations #2 in Section 2.3 of R1-2009609 are agreed to supersede the previously agreed corresponding observations.

9 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [25, NTT DOCOMO], [12, Intel], [58, Nokia]) reported evaluation results of PRACH preamble detection performance in terms of SINR in dB achieving PRACH preamble misdetection probability of 1% with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808.  Two sources ([14, 61, Ericsson], [19, OPPO]) compared link budget of PRACH for different SCS.

The following are observed.

* For PRACH preamble detection performances for the same PRACH format, all evaluated candidate SCSs (120, 240, 480 and 960 kHz) show comparable performances
	+ Note: The following references were used to derive the observations.
	+ 8 out of 9 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 kHz). The other source ([64, OPPO]) reported minor performances difference among all SCS for TDL-A with 5 and 10ns DS. It reported infinite SINR for 960 kHz SCS and comparable SINR for 120, 240 and 480 kHz SCS in TDL-A with 20ns DS using the metrics of preamble miss detection probability of 1% and the estimated timing error is within [-Tcp/2, Tcp/2].
* For PRACH link budget of the same PRACH format and the same sequence length, maximum isotropic loss (MIL) and maximum coupling loss (MCL) degrade as the subcarrier spacing is increased, negatively impacting coverage.
	+ Two sources ([14, 61, Ericsson], [19, OPPO]) reported that with UE power limitation of 25 dBm EIRP, the MCL/MIL difference between 120 KHz SCS and 480 KHz SCS is about 4 to 5 dB; the MCL/MIL difference between 120 KHz SCS and 960 KHz SCS is about 8 dB.
	+ One source ([14, 61, Ericsson]) reported that without UE power limitation of 25 dBm EIRP (but still under regulatory limits), the MCL difference between 120 kHz SCS and 480 kHz SCS is less than 2.5 dB; the MCL difference between 120 kHz SCS and 960 kHz SCS is less than 1 dB.
	+ One source ([14, 61, Ericsson]) reported that without UE power limitation of 25 dBm EIRPs (but still under regulatory limits), compared to short PRACH sequence length, longer PRACH sequence length improve MCL/MIL significantly for 120 kHz SCS due to wider bandwidth for a given SCS.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.3**

9 sources, [65], [72], [30], [60], [64], [68], [29], [16] and [62], reported evaluation results of PRACH preamble detection performance in terms of SINR in dB achieving PRACH preamble misdetection probability of 1% with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808. Two sources, [65], and [23], compared link budget of PRACH for different SCS. The following are observed:* For PRACH preamble detection performances for the same PRACH format, all evaluated candidate SCSs (120, 240, 480 and 960 kHz) show comparable performances
	+ 8 out of 9 sources reported minor performance difference (< or ~ 1 dB) between adjacent SCS for all evaluated candidate SCSs (120, 240, 480 and 960 kHz). The other source [68] reported minor performances difference among all SCS for TDL-A with 5 and 10ns delay spread. It reported infinite SINR for 960 kHz SCS and comparable SINR for 120, 240 and 480 kHz SCS in TDL-A with 20ns delay spread using the metrics of preamble miss detection probability of 1% and the estimated timing error is within [-Tcp/2, Tcp/2].
* For PRACH link budget of the same PRACH format and the same sequence length, maximum isotropic loss (MIL) and maximum coupling loss (MCL) degrade as the subcarrier spacing is increased, negatively impacting coverage.
	+ Two sources, [65], and [23], reported that with UE power limitation of 25 dBm EIRP, the MCL/MIL difference between 120 kHz SCS and 480 kHz SCS is about 4 to 5 dB; the MCL/MIL difference between 120 kHz SCS and 960 kHz SCS is about 8 dB.
	+ One source [65] reported that without UE power limitation of 25 dBm EIRP (but still under regulatory limits), the MCL difference between 120 kHz SCS and 480 kHz SCS is less than 2.5 dB; the MCL difference between 120 kHz SCS and 960 kHz SCS is less than 1 dB.
	+ One source [65] reported that without UE power limitation of 25 dBm EIRPs (but still under regulatory limits), compared to short PRACH sequence length, longer PRACH sequence length improve MCL/MIL significantly for 120 kHz SCS due to wider bandwidth for a given SCS.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |
| vivo | Section 6.1.3, “Two sources, [65], and [20], compared link budget of PRACH for different SCS.” should be “Two sources, [65], and [23], compared link budget of PRACH for different SCS.” |
| Moderator | Updated as corrected by vivo. |

### Agreement #29:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

For CP-OFDM, the following are observed regarding the impact of DMRS to BLER performance.

* One source ([57, InterDigital]) reported performance improvement with increased number of DMRS symbols or increased DMRS density especially for higher modulation order for 960 kHz SCS in TDL-A (5 ns and 10 ns delay spread).
* One source ([14, Ericsson]) reported for 480 kHz SCS and below with large delay spread (TDL-A with 40 ns delay spread), the room for performance improvement with a change to the Rel-15 DMRS design is very limited.
* One source ([12, Intel]) reported a performance drop when frequency domain OCC is enabled especially for higher order modulation such as 64 QAM (MCS 22) for 960 kHz SCS in TDL-A (10ns and 20 ns delay spread) and 480 kHz SCS (20 ns delay spread). The performance gap increases when channel delay spread increases.
* One source ([26, Qualcomm]) reported performance improvement with a new DMRS pattern featured by high frequency density (i.e., every RE) and 2-FD-OCC across adjacent REs for 960 kHz SCS in TDL-A (20 ns and 40 ns delay spread)..
* One source ([10, Nokia]) reported that with Rel-15 DMRS type-1, different delay spread values (10ns and 20ns) have a negligible impact to the demodulation performance of PDSCH for a high SCS (such as 960 kHz).

### Agreement #54 (replace #29):

Summary observations #2 in Section 2.1.5 of R1-2009609 are agreed to supersede the previously agreed corresponding observations.

For CP-OFDM, the following are observed regarding the impact of DMRS to BLER performance.

* One source ([57, InterDigital]) reported performance improvement with increased number of DMRS symbols or increased DMRS density especially for higher modulation order for 960 kHz SCS in TDL-A (5 ns and 10 ns delay spread).
* One source ([14, Ericsson]) reported for 480 kHz SCS and below with large delay spread (TDL-A with 40 ns delay spread), the room for performance improvement with a change to the Rel-15 DMRS design is very limited.
* One source ([12, Intel]) reported a performance drop when frequency domain OCC is enabled especially for higher order modulation such as 64 QAM (MCS 22) for 960 kHz SCS in TDL-A (10ns and 20 ns delay spread) and 480 kHz SCS (20 ns delay spread). The performance gap increases when channel delay spread increases.
* One source ([26, Qualcomm]) reported performance improvement with a new DMRS pattern featured by high frequency density (i.e., every RE) and 2-FD-OCC across adjacent REs for 960 kHz SCS in TDL-A (20 ns and 40 ns delay spread).
* One source ([10, Nokia]) reported that with Rel-15 DMRS type-1, different delay spread values (10ns and 20ns) have a negligible impact to the demodulation performance of PDSCH for a high SCS (such as 960 kHz).
* One source ([64, OPPO]) reported that with high SCS (960 kHz) in TDL-A 20ns delay spread, the frequency domain selectivity will introduce non-orthogonality among subcarriers when FD-OCC is applied, which further leads to some performance degradation for MCS 16.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.1**

For CP-OFDM, the following are observed regarding the impact of DMRS to BLER performance. * One source [61] reported performance improvement with increased number of DMRS symbols or increased DMRS density especially for higher modulation order for 960 kHz SCS in TDL-A (5 ns and 10 ns delay spread).
* One source [18] reported for 480 kHz SCS and below with large delay spread (TDL-A with 40 ns delay spread), the room for performance improvement with a change to the Rel-15 DMRS design is very limited.
* One source [16] reported a performance drop when frequency domain OCC is enabled especially for higher order modulation such as 64 QAM (MCS 22) for 960 kHz SCS in TDL-A (10ns and 20 ns delay spread) and 480 kHz SCS (20 ns delay spread). The performance gap increases when channel delay spread increases.
* One source [30] reported performance improvement with a new DMRS pattern featured by high frequency density (i.e., every RE) and 2-FD-OCC across adjacent REs for 960 kHz SCS in TDL-A (20 ns and 40 ns delay spread)..
* One source [14] reported that with Rel-15 DMRS type-1, different delay spread values (10ns and 20ns) have a negligible impact to the demodulation performance of PDSCH for a high SCS (such as 960 kHz).
* One source [68] reported that with high SCS (960 kHz) in TDL-A 20ns delay spread, the frequency domain selectivity will introduce non-orthogonality among subcarriers when FD-OCC is applied, which further leads to some performance degradation for MCS 16.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |

### Agreement #30:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

7 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [64, OPPO], [10, Nokia], [21, Apple]) evaluated DFT-S-OFDM PUSCH BLER performance with different SCS.

* Compared to CP-OFDM when CPE-only compensation is enabled, DFT-s-OFDM is more robust under phase noise.
* For low and medium MCSs (QPSK and 16QAM), there’s minor performance difference among evaluated SCSs up to 960 kHz.
* With normal CP, for high MCS (64QAM), the performance improves as the increase of SCS, 120 kHz SCS shows up to ~2.0dB loss compared to other larger SCS.
	+ Note: the following are references when derive the observations.
	+ One source ([61, Ericsson]) reported a performance gap of 1.4 ~ 1.8 dB between 120 and 960 kHz SCS.
	+ One source ([68, Huawei]) reported a performance gap of 1.3 ~ 2.5 dB between 120 and 960 kHz SCS.
	+ One source ([26, Qualcomm]) reported a performance gap of 1.2 ~ 1.7 dB between 120 and 960 kHz SCS.
	+ One source ([56, vivo]) reported a performance gap of ~ 1.4 dB between 120 and 960 kHz SCS.
	+ One source ([10, Nokia]) did not report numerical SINR results in table but provided figures showing approximately similar performance difference, ~ 2 dB, between 120 and 960 kHz SCS.
	+ One source ([21, Apple]) reported a performance gap of more than 7 dB performance gap between 120 kHz SCS and other SCS (240, 480 and 960 kHz) at TDL-A 5 ns DS. It also reported 120 kHz SCS cannot meet the BLER target of 10% at TDL-A 10ns DS and 960 kHz SCS cannot meet the BLER target of 10% at TDL-A 20ns DS.
	+ Another source ([64, OPPO]) reported 120 and 240 kHz SCS cannot meet the BLER target of 10% for all evaluated DS values.
* For high MCS (64QAM) at large delay spread (TDL-A 40ns or CDL-B 50ns DS), there’s error floor for 960 KHz SCS at least for BLER target 1%.
	+ Note: the following are reference when derive the observations.
	+ One source ([26, Qualcomm]) reported an error floor for 960 kHz SCS for BLER target 1%.
	+ One source ([56, vivo]) reported an error floor for 960 kHz SCS for BLER target 10%
	+ One source ([64, OPPO]) reported no error floor of 960 kHz SCS for the BLER target of 10% and 1% for CDL-B 50ns but an error floor for 960 kHz SCS at TDL-A 20ns for BLER target 1%

### Agreement #52 (replaced #30):

Summary observations #2 in Section 2.1.3 of R1-2009609 are agreed to supersede the previously agreed corresponding observations.

8 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [21, Apple]) evaluated DFT-S-OFDM PUSCH BLER performance with different SCS.

* Compared to CP-OFDM when CPE-only compensation is enabled, DFT-s-OFDM is more robust under phase noise.
* For low and medium MCSs (QPSK and 16QAM), there’s minor performance difference among evaluated SCSs up to 960 kHz.
* With normal CP, for high MCS (64QAM), the performance improves as the increase of SCS, 120 kHz SCS shows up to ~2.0dB loss compared to other larger SCS.
	+ Note: the following are references when derive the observations.
	+ One source ([61, Ericsson]) reported a performance gap of 1.4~1.8 dB between 120 and 960 kHz SCS
	+ One source ([68, Huawei]) reported a performance gap of 1.3~2.5 dB between 120 and 960 kHz SCS
	+ One source ([26, Qualcomm]) reported a performance gap of 1.2~1.7 dB between 120 and 960 kHz SCS
	+ One source ([56, vivo]) reported a performance gap of ~1.4 dB between 120 and 960 kHz SCS
	+ One source ([60, ZTE]) reported a performance gap of 1.4~1.8 dB between 120 and 960 kHz SCS
	+ One source ([10, Nokia]) did not report numerical SINR results in table but provided figures showing approximately similar performance difference (~ 2 dB) between 120 and 960 kHz SCS.
	+ One source ([21, Apple]) reported a performance gap of more than 7 dB performance gap between 120 kHz SCS and other SCS (240, 480 and 960 kHz) at TDL-A 5 ns DS. It also reported 120 kHz SCS cannot meet the BLER target of 10% at TDL-A 10ns DS and 960 kHz SCS cannot meet the BLER target of 10% at TDL-A 20ns DS.
	+ Another source ([64, OPPO]) reported 120 and 240 kHz SCS cannot meet the BLER target of 10% for all evaluated DS values.
* For high MCS (64QAM) at large delay spread (TDL-A 40ns or CDL-B 50ns DS), there’s error floor for 960 KHz SCS at least for BLER target 1%.
	+ Note: the following are reference when derive the observations.
	+ One source ([26, Qualcomm]) reported an error floor for 960 kHz SCS for BLER target 1%.
	+ One source ([56, vivo]) reported an error floor for 960 kHz SCS for BLER target 10%
	+ One source ([64, OPPO]) reported no error floor of 960 kHz SCS for the BLER target of 10% and 1% for CDL-B 50ns but an error floor for 960 kHz SCS at TDL-A 20ns for BLER target 1%

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.1**

8 sources, [65], [72], [30], [60], [64], [68], [14], and [25], evaluated DFT-S-OFDM PUSCH BLER performance with different SCS. * Compared to CP-OFDM when CPE-only compensation is enabled, DFT-s-OFDM is more robust under phase noise.
* For low and medium MCSs (QPSK and 16QAM), there’s minor performance difference among evaluated SCSs up to 960 kHz.
* With normal CP, for high MCS (64QAM), the performance improves as the increase of SCS, 120 kHz SCS shows up to ~2.0dB loss compared to other larger SCS.
	+ One source [65] reported a performance gap of 1.4~1.8 dB between 120 and 960 kHz SCS.
	+ One source [72] reported a performance gap of 1.3~2.5 dB between 120 and 960 kHz SCS.
	+ One source [30] reported a performance gap of 1.2~1.7 dB between 120 and 960 kHz SCS.
	+ One source [60] reported a performance gap of ~1.4 dB between 120 and 960 kHz SCS
	+ One source [64] reported a performance gap of 1.4~1.8 dB between 120 and 960 kHz SCS
	+ One source [14] did not report numerical SINR results in table but provided figures showing approximately similar performance difference (~ 2 dB) between 120 and 960 kHz SCS.
	+ One source [25] reported a performance gap of more than 7 dB performance gap between 120 kHz SCS and other SCS (240, 480 and 960 kHz) at TDL-A 5 ns DS. It also reported 120 kHz SCS cannot meet the BLER target of 10% at TDL-A 10ns DS and 960 kHz SCS cannot meet the BLER target of 10% at TDL-A 20ns DS.
	+ Another source [68] reported 120 and 240 kHz SCS cannot meet the BLER target of 10% for all evaluated DS values.
* For high MCS (64QAM) at large delay spread (TDL-A 40ns or CDL-B 50ns DS), there’s error floor for 960 kHz SCS at least for BLER target 1%.
	+ One source [30] reported an error floor for 960 kHz SCS for BLER target 1%.
	+ One source [60] reported an error floor for 960 kHz SCS for BLER target 10%.
	+ One source [68] reported no error floor of 960 kHz SCS for the BLER target of 10% and 1% for CDL-B 50ns but an error floor for 960 kHz SCS at TDL-A 20ns for BLER target 1%.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |

### Agreement #31:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

For CP-OFDM, with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808, the following are observed when CPE-only compensation based on the existing Rel-15 NR PTRS structure is used for normal CP when delay spread is not large. The performance is measured in terms of SINR in dB achieving BLER target of 10% or 1%.

* For low MCS (QPSK) and medium MCS (16QAM), there is minor performance difference between different SCS values up to 960 kHz.
* For high MCS (64QAM), the performance improves in general as the increase of SCS
* For high MCS (64QAM), 13 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [21, Apple], [18, Samsung], [25, NTT DOCOMO], [12, Intel], [7, InterDigital]) compared performance of 120 and 240 kHz SCS in 400 MHz bandwidth
	+ for 10% BLER target, there is a performance gap between 120kHz and 240kHz SCS where 240 kHz SCS performs better.
		- Note: the following references are used when derive the observations.
		- One source ([61, Ericsson]) reported better performance of 240 kHz SCS in CDL-D. It also reported both SCS cannot meet 10% BLER target for other evaluated channel model.
		- 3 sources ([68, Huawei], [64, OPPO], [10, Nokia]) reported both SCS cannot meet 10% BLER target
		- 4 sources ([56, vivo], [60, ZTE], [21, Apple], [7, InterDigital]) reported 120 kHz SCS cannot meet 10% BLER target while 240 kHz SCS can
		- One source ([2, 55, Lenovo]) reported better performance of 240 kHz SCS at TDL-A 5 and 10ns. It also reported that both SCS cannot meet 10% BLER target for other evaluated cases.
		- One source ([12, Intel]) reported better performance of 240 kHz SCS in CDL-D. It also reported that both SCS cannot meet 10% BLER target for other evaluated cases.
		- 2 sources ([26, Qualcomm], [18, Samsung]) reported better performance of 240 kHz SCS
		- One source ([25, NTT DOCOMO]) reported comparable performance for both SCS in CDL-D. It also reported better performance of 120 kHz SCS for other evaluated channel model.
* For high MCS (64QAM), 13 sources ([61, Ericsson], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [21, Apple], [18, Samsung], [25, NTT DOCOMO], [12, Intel], [67, Charter], [7, InterDigital]) compared performance of 240 and 480 kHz SCS in 400 MHz bandwidth
	+ for 10% BLER target, there is a performance gap between 240kHz and 480kHz SCS where 480 kHz SCS performs better.
		- Note: the following references are used when derive the observations.
		- One source ([61, Ericsson]) reported better performance for 480 kHz SCS in CDL-D. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated channel model.
		- 3 sources ([64, OPPO], [10, Nokia], [67, Charter]) reported 240 kHz SCS cannot meet 10% BLER target while 480 kHz SCS can
		- One source ([2, 55, Lenovo]) reported better performance of 480 kHz SCS at TDL-A 5 and 10ns. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated cases.
		- One source ([12, Intel]) reported better performance of 480 kHz SCS in CDL-D. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated cases.
		- 6 sources ([26, Qualcomm], [56, vivo], [60, ZTE], [21, Apple], [18, Samsung], [7, InterDigital]) reported better performance of 480 kHz SCS
		- One source ([25, NTT DOCOMO]) reported comparable performance for both SCS in CDL-D. It also reported better performance of 240 kHz SCS for other evaluated channel model.
* For high MCS (64QAM), 14 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [21, Apple], [18, Samsung], [25, NTT DOCOMO], [12, Intel], [67, Charter], [7, InterDigital]) compared performance of 480 and 960 kHz SCS in 400 MHz bandwidth
	+ for 10% BLER target, there is a performance gap between 480kHz and 960kHz SCS where 960 KHz SCS performs better.
		- Note: the following references are used when derive the observations.
		- 7 sources ([61, Ericsson], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [67, Charter], [7, InterDigital]) reported a greater than 1 dB gain of 960 kHz SCS
		- 3 sources ([26, Qualcomm], [56, vivo], [18, Samsung]) reported a smaller than 1 dB performance gain of 960 kHz SCS
		- One source ([68, Huawei]) reported better performance of 480 kHz SCS for CDL-B 50ns and better performance of 960 kHz SCS for other evaluated cases. In all comparison, the difference is greater than 1 dB.
		- Two sources ([21, Apple], [12, Intel]) reported a better performance of 480 kHz SCS than 960 kHz SCS at 20ns DS in TDL-A where 960 kHz SCS cannot meet 10% BLER target and comparable performance for both SCS in all other evaluated cases
		- One source ([25, NTT DOCOMO]) reported comparable performance for both SCS in CDL-D. It also reported better performance of 480 kHz SCS in TDL-A 5ns and better performance of 960 kHz SCS in CDL-B 20ns.
	+ for 1% BLER target, the performance for 960kHz SCS is better than 480kHz SCS.
		- Among sources reported SINR values when both SCS can meet 1% BLER target, the absolute value of the performance gap between 480 kHz and 960 kHz SCS is larger than that for 10% BLER target.
* For high MCS (64QAM), 4 sources ([61, Ericsson], [56, vivo], [10, Nokia], [18, Samsung]) compared performance of 480 and 960 kHz SCS in 1600 or 2000 MHz bandwidth. 4 out of 4 sources reported performance gain around 4 ~ 5 dB of 960 kHz SCS for 10% BLER target. All 4 sources also reported that 480 kHz SCS cannot meet 1% BLER target.

### Agreement #51 (replace #31):

Summary observations #2a in Section 2.1.1.2 of R1-2009609 are agreed to supersede the previously agreed corresponding observations.

For CP-OFDM, with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808, the following are observed when CPE-only compensation based on the existing Rel-15 NR PTRS structure is used for normal CP when delay spread is not large. The performance is measured in terms of SINR in dB achieving BLER target of 10% or 1%.

* For low MCS (QPSK) and medium MCS (16QAM), there is minor performance difference between different SCS values up to 960 kHz.
* For high MCS (64QAM), the performance improves in general as the increase of SCS
* For high MCS (64QAM), 15 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [21, Apple], [18, Samsung], [25, NTT DOCOMO], [12, Intel], [67, Charter], [7, InterDigital], [15, LG]) compared performance of 120 and 240 kHz SCS in 400 MHz bandwidth
	+ for 10% BLER target, there is a performance gap between 120kHz and 240kHz SCS where 240 kHz SCS performs better.
		- Note: the following references are used when derive the observations.
		- One source ([61, Ericsson]) reported better performance of 240 kHz SCS in CDL-D. It also reported both SCS cannot meet 10% BLER target for other evaluated channel model.
		- 4 sources ([68, Huawei], [64, OPPO], [10, Nokia], [67, Charter]) reported both SCS cannot meet 10% BLER target
		- 4 sources ([56, vivo], [60, ZTE], [21, Apple], [7, InterDigital]) reported 120 kHz SCS cannot meet 10% BLER target while 240 kHz SCS can
		- One source ([2, 55, Lenovo]) reported better performance of 240 kHz SCS at TDL-A 5 and 10ns. It also reported that both SCS cannot meet 10% BLER target for other evaluated cases.
		- One source ([12, Intel]) reported better performance of 240 kHz SCS in CDL-D. It also reported that both SCS cannot meet 10% BLER target for other evaluated cases.
		- 3 sources ([26, Qualcomm], [18, Samsung], [15, LG]) reported better performance of 240 kHz SCS
		- One source ([25, NTT DOCOMO]) reported comparable performance for both SCS in CDL-D. It also reported better performance of 120 kHz SCS for other evaluated channel model.
* For high MCS (64QAM), 14 sources ([61, Ericsson], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [21, Apple], [18, Samsung], [25, NTT DOCOMO], [12, Intel], [67, Charter], [7, InterDigital], [15, LG]) compared performance of 240 and 480 kHz SCS in 400 MHz bandwidth
	+ for 10% BLER target, there is a performance gap between 240kHz and 480kHz SCS where 480 kHz SCS performs better.
		- Note: the following references are used when derive the observations.
		- One source ([61, Ericsson]) reported better performance for 480 kHz SCS in CDL-D. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated channel model.
		- 3 sources ([64, OPPO], [10, Nokia], [67, Charter]) reported 240 kHz SCS cannot meet 10% BLER target while 480 kHz SCS can
		- One source ([2, 55, Lenovo]) reported better performance of 480 kHz SCS at TDL-A 5 and 10ns. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated cases.
		- One source ([12, Intel]) reported better performance of 480 kHz SCS in CDL-D. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated cases.
		- 7 sources ([26, Qualcomm], [56, vivo], [60, ZTE], [21, Apple], [18, Samsung], [7, InterDigital], [15, LG]) reported better performance of 480 kHz SCS
		- One source ([25, NTT DOCOMO]) reported comparable performance for both SCS in CDL-D. It also reported better performance of 240 kHz SCS for other evaluated channel model.
* For high MCS (64QAM), 15 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [21, Apple], [18, Samsung], [25, NTT DOCOMO], [12, Intel], [67, Charter], [7, InterDigital], [15, LG]) compared performance of 480 and 960 kHz SCS in 400 MHz bandwidth
	+ for 10% BLER target, there is a performance gap between 480kHz and 960kHz SCS where 960 KHz SCS performs better.
		- Note: the following references are used when derive the observations.
		- 7 sources ([61, Ericsson], [60, ZTE], [64, OPPO], [10, Nokia], [2, 55, Lenovo], [67, Charter], [7, InterDigital]) reported a greater than 1 dB gain of 960 kHz SCS
		- 3 sources ([26, Qualcomm], [56, vivo], [18, Samsung]) reported a smaller than 1 dB performance gain of 960 kHz SCS
		- One source ([68, Huawei]) reported better performance of 480 kHz SCS for CDL-B 50ns and better performance of 960 kHz SCS for other evaluated cases. In all comparison, the difference is greater than 1 dB.
		- Two sources ([21, Apple], [12, Intel]) reported a better performance of 480 kHz SCS than 960 kHz SCS at 20ns DS in TDL-A where 960 kHz SCS cannot meet 10% BLER target and comparable performance for both SCS in all other evaluated cases
		- One source ([25, NTT DOCOMO]) reported comparable performance for both SCS in CDL-D. It also reported better performance of 480 kHz SCS in TDL-A 5ns and better performance of 960 kHz SCS in CDL-B 20ns.
		- One source ([15, LG]) reported a smaller than 1 dB performance gain of 960 kHz SCS at 5ns and 10ns in TDL-A and a smaller than 1 dB performance gain of 480 kHz SCS at 20ns in TDL-A.
	+ for 1% BLER target, the performance for 960kHz SCS is better than 480kHz SCS.
		- Among sources reported SINR values when both SCS can meet 1% BLER target, the absolute value of the performance gap between 480 kHz and 960 kHz SCS is larger than that for 10% BLER target.
* For high MCS (64QAM), 4 sources ([61, Ericsson], [56, vivo], [10, Nokia], [18, Samsung]) compared performance of 480 and 960 kHz SCS in 1600 or 2000 MHz bandwidth. 4 out of 4 sources reported performance gain around 4 ~ 5 dB of 960 kHz SCS for 10% BLER target. All 4 sources also reported that 480 kHz SCS cannot meet 1% BLER target.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):**** **Capture text above under Section 6.1.1**

For CP-OFDM, with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808, the following are observed when CPE-only compensation based on the existing Rel-15 NR PTRS structure is used for normal CP when delay spread is not large. The performance is measured in terms of SINR in dB achieving BLER target of 10% or 1%.* For low MCS (QPSK) and medium MCS (16QAM), there is minor performance difference between different SCS values up to 960 kHz.
* For high MCS (64QAM), the performance improves in general as the increase of SCS.
* For high MCS (64QAM), 15 sources, [65], [72], [30], [60], [64], [68], [14], [6], [59], [25], [22], [29], [16], [71], [11], and [19],, compared performance of 120 and 240 kHz SCS in 400 MHz bandwidth.
	+ For 10% BLER target, there is a performance gap between 120kHz and 240kHz SCS where 240 kHz SCS performs better.
		- One source [65] reported better performance of 240 kHz SCS in CDL-D. It also reported both SCS cannot meet 10% BLER target for the other evaluated channel models.
		- 4 sources, [72], [68], [14], and [71],, reported both SCS cannot meet 10% BLER target.
		- 4 sources, [60], [64], [25], and [11], reported 120 kHz SCS cannot meet 10% BLER target, while 240 kHz SCS can.
		- One source, [6] and additional results in [59], reported better performance of 240 kHz SCS at TDL-A 5 and 10ns. It also reported that both SCS cannot meet 10% BLER target for other evaluated cases.
		- One source [16] reported better performance of 240 kHz SCS in CDL-D. It also reported that both SCS cannot meet 10% BLER target for other evaluated cases.
		- 3 sources, [30], [22], and [19],, reported better performance of 240 kHz SCS.
		- One source [29], reported comparable performance for both SCS in CDL-D. It also reported better performance of 120 kHz SCS for the other evaluated channel models.
* For high MCS (64QAM), 14 sources, [65], [30], [60], [64], [68], [14], [6], [59], [25], [22], [29], [16], [71], [11], and [19],, compared performance of 240 and 480 kHz SCS in 400 MHz bandwidth.
	+ for 10% BLER target, there is a performance gap between 240kHz and 480kHz SCS where 480 kHz SCS performs better.
		- One source [65] reported better performance for 480 kHz SCS in CDL-D. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated channel model.
		- 3 sources, [68], [14], and [71], reported 240 kHz SCS cannot meet 10% BLER target, while 480 kHz SCS can.
		- One source [6] and additional results in [59], reported better performance of 480 kHz SCS at TDL-A 5 and 10ns. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated cases.
		- One source [16] reported better performance of 480 kHz SCS in CDL-D. It also reported 240 kHz SCS cannot meet 10% BLER target for other evaluated cases.
		- 7 sources, [30], [60], [64], [25], [22], [11], and [19], reported better performance of 480 kHz SCS.
		- One source [29], reported comparable performance for both SCS in CDL-D. It also reported better performance of 240 kHz SCS for the other evaluated channel models.
* For high MCS (64QAM), 15 sources, [65], ,[72], [30], [60], [64], [68], [14], [6], [59], [25], [22], [29], [16], [71], and [11] and [19], compared performance of 480 and 960 kHz SCS in 400 MHz bandwidth.
	+ For 10% BLER target, there is a performance gap between 480kHz and 960kHz SCS where 960 kHz SCS performs better.
		- 7 sources, [65], [64], [68], [14], [6], [59], [71], and [11], reported a greater than 1 dB gain of 960 kHz SCS.
		- 3 sources, [30], [60], and [22], reported a smaller than 1 dB performance gain of 960 kHz SCS.
		- One source [72] reported better performance of 480 kHz SCS for CDL-B 50ns and better performance of 960 kHz SCS for other evaluated cases. In all comparison, the difference is greater than 1 dB.
		- Two sources, [25], [16], reported a better performance of 480 kHz SCS than 960 kHz SCS at 20ns DS in TDL-A where 960 kHz SCS cannot meet 10% BLER target and comparable performance for both SCS in all other evaluated cases.
		- One source [29] reported comparable performance for both SCS in CDL-D. It also reported better performance of 480 kHz SCS in TDL-A 5ns and better performance of 960 kHz SCS in CDL-B 20ns.
		- One source [19] reported a smaller than 1 dB performance gain of 960 kHz SCS at 5 ns and 10 ns in TDL-A and a smaller than 1 dB performance gain of 480 kHz SCS at 20 ns in TDL-A.
	+ For 1% BLER target, the performance for 960kHz SCS is better than 480kHz SCS.
		- Among sources reported SINR values when both SCS can meet 1% BLER target, the absolute value of the performance gap between 480 kHz and 960 kHz SCS is larger than that for 10% BLER target.
* For high MCS (64QAM), 4 sources, [65], [60], [14], and [22], compared performance of 480 and 960 kHz SCS in 1600 or 2000 MHz bandwidth. 4 out of 4 sources reported performance gain around 4 ~ 5 dB of 960 kHz SCS for 10% BLER target. All 4 sources also reported that 480 kHz SCS cannot meet 1% BLER target.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |

### Agreement #32:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

For CP-OFDM, with evaluation assumptions and parameters as in Table A.1-1 of TR 38.808 (including optional delay spread value), the following are observed when CPE-only compensation based on the existing Rel-15 NR PTRS structure is used with respect to CP type and large delay spread.

* When delay spread is not large (< 40 ns in TDL-A), there is minor performance difference between normal and extended CP for SCS values up to 960 kHz when compared on the basis of equal MCS (code rate). If comparing on the basis of equal TBS (equal throughput), the performance of ECP is degraded due to higher overhead of ECP.
* Among 11 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [2, 55, Lenovo], [1, Futurewei], [25, NTT DOCOMO], [12, Intel], [7, InterDigital]) evaluated with large delay spread (i.e. 40 ns in TDL-A and/or 50ns in CDL) based on the existing Rel-15 NR PTRS structure for normal CP, 10 sources observed that for low MCS (QPSK) and medium MCS (16QAM), there is minor performance difference between different SCS values up to 960kHz for 10% BLER target
	+ The other source ([1, Futurewei]) evaluated SCS 960 kHz with CPE compensation at MCS16 with normal CP in TDL-A channel with 40ns DS. It reported that the BLER for SCS 960 kHz, MCS16, and Normal CP is not acceptable (cannot meet 10% BLER target) for 40ns DS.
* 10 sources ([61, Ericsson], [68, Huawei], [26, Qualcomm], [56, vivo], [60, ZTE], [64, OPPO], [2, 55, Lenovo], [25, NTT DOCOMO], [12, Intel], [7, InterDigital]) evaluated large delay spread (i.e. 40 ns in TDL-A and/or 50ns in CDL) with CPE compensation based on the existing Rel-15 NR PTRS structure with normal CP. Among 10 sources, 5 sources ([14, Ericsson], [68, Huawei], [5, 56, vivo], [2, 55, Lenovo], [25, NTT DOCOMO]) also evaluated extended CP at least for 960 kHz SCS with CPE compensation based on the existing Rel-15 NR PTRS structure.
	+ 9 out 10 sources observed that for high MCS (64QAM) with normal CP, larger SCS (480 and 960 kHz) performs better than smaller SCS (120 and 240 kHz) when only CPE compensation based on the existing Rel-15 NR PTRS structure is used. The other source ([25, NTT DOCOMO]) reported better performance of smaller SCS.
	+ 5 out 5 sources observed the performance of 960 kHz SCS with extended CP is significantly improved compared to with normal CP for large delay spread case when compared on the basis of equal MCS (code rate).
	+ 4 sources ([14, Ericsson], [68, Huawei], [5, vivo], [2, 55, Lenovo]) compared throughput of normal CP and extended CP at least for 960 kHz SCS with CPE compensation based on the existing Rel-15 NR PTRS structure. They all reported worse throughput of extended CP.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.1**

For CP-OFDM, with evaluation assumptions and parameters as in Table A.1-1 (including optional delay spread value), the following are observed when CPE-only compensation based on the existing Rel-15 NR PTRS structure is used with respect to CP type and large delay spread. * When delay spread is not large (< 40 ns in TDL-A), there is minor performance difference between normal and extended CP for SCS values up to 960 kHz when compared on the basis of equal MCS (code rate). If comparing on the basis of equal TBS (equal throughput), the performance of ECP is degraded due to higher overhead of ECP.
* Among 11 sources, [65], [72], [30], [60], [64], [68], [6], [59], [5], [29], [16], and [11], evaluated with large delay spread (i.e. 40 ns in TDL-A and/or 50ns in CDL) based on the existing Rel-15 NR PTRS structure for normal CP, 10 sources observed that for low MCS (QPSK) and medium MCS (16QAM), there is minor performance difference between different SCS values up to 960kHz for 10% BLER target.
	+ The other source [5] evaluated SCS 960 kHz with CPE compensation at MCS16 with normal CP in TDL-A channel with 40ns DS. It reported that the BLER for SCS 960 kHz, MCS16, and Normal CP is not acceptable (cannot meet 10% BLER target) for 40ns DS.
* 10 sources, [65], [72], [30], [60], [64], [68], [6], [59], [29], [16], and [11], evaluated large delay spread (i.e. 40 ns in TDL-A and/or 50ns in CDL) with CPE compensation based on the existing Rel-15 NR PTRS structure with normal CP. Among 10 sources, 5 sources, [18], [72], [9], [60], [6], [59], and [29], also evaluated extended CP at least for 960 kHz SCS with CPE compensation based on the existing Rel-15 NR PTRS structure.
	+ 9 out 10 sources observed that for high MCS (64QAM) with normal CP, larger SCS (480 and 960 kHz) performs better than smaller SCS (120 and 240 kHz) when only CPE compensation based on the existing Rel-15 NR PTRS structure is used. The other source [29] reported better performance of smaller SCS.
	+ 5 out 5 sources observed the performance of 960 kHz SCS with extended CP is significantly improved compared to with normal CP for large delay spread case when compared on the basis of equal MCS (code rate).
	+ 4 sources, [18], [72], [9], [6], and [59], compared throughput of normal CP and extended CP at least for 960 kHz SCS with CPE compensation based on the existing Rel-15 NR PTRS structure. They all reported worse throughput of extended CP.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |

### Agreement #33:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

For CP-OFDM, the following are observed with respect to phase noise compensation and PTRS.

* Compared to no phase noise compensation, CPE compensation shows little gain at low and medium MCSs for all the evaluated SCS values; while significant gain is observed for high MCS (64QAM) for all the evaluated SCS values.
	+ Two sources ([57, InterDigital], [11, Mitsubishi])) reported that increased PTRS density in frequency domain based on Rel-15 configuration does not provide significant performance benefits.
* For a given SCS, the complexity of ICI compensation increases as the number of ICI filter tap increases
* For MCS 22 evaluation of the same SCS, performance gain of ICI compensation with additional complexity of multi-tap filtering compared to CPE-only compensation is observed when there is sufficient number of PTRS in the frequency domain for 120, 240 and 480 kHz SCS.
	+ Note: the following references are used when derive the observations.
	+ One source ([61, Ericsson]) showed performance gain of ICI compensation compared to CPE-only compensation for all evaluated SCS
	+ One source ([68, Huawei]) evaluated ICI compensation and compared with CPE-only compensation. It reported performance gain for all evaluated SCS.
	+ One source ([26, Qualcomm]) compared the performance of CPE and ICI compensation for 120 kHz SCS reported performance gain of ICI compensation.
	+ One source ([64, OPPO]) compared the performance of CPE and ICI compensation for all SCS. It reported performance gain of ICI compensation for 240 kHz and 480 kHz SCS. It reported performance gain of ICI compensation in CDL-B but a performance loss in TDL-A for 960 kHz SCS. It also reported that 120 kHz SCS still cannot meet 10% BLER target with ICI compensation.
	+ One source ([10, Nokia]) reported performance gain of ICI compensation for 120, 240 and 480 kHz SCS. It also reported performance gain of ICI compensation for 960 kHz SCS at 2GHz bandwidth and a performance loss of ICI compensation for 960 kHz SCS at 400MHz bandwidth.
	+ One source ([65, Apple]) evaluated ICI compensation for different SCS with a new PTRS pattern. It reported improvement of ICI compensation compared to CPE-only compensation.
	+ One source ([18, Samsung]) evaluated 120 kHz and 240 kHz SCS performance with ICI compensation based on some new PTRS pattern and reported performance improvement.
	+ One source ([1, Futurewei]) compared ICI performance among SCS. It reported performance gain of multi-tap ICI filter over CPE compensation for 120, 240 and 480 kHz SCS
	+ One source ([12, Intel]) evaluated performance of de-ICI method for MCS 22 with small RB allocations for 240, 480 and 960 KHz SCS. It is observed that the de-ICI method do not work when there isn’t sufficient number of PTRS tones in the frequency domain.
* For MCS 22 with normal CP when delay spread is not large, it is observed that ICI compensation of multi-tap filtering is required for 120, 240 and/or 480 kHz SCS to achieve comparable performance (< 1 dB difference) to that of 960 kHz SCS with CPE-only compensation for 10% BLER target
	+ Note: the following references are used when derive the observations.
	+ 2 sources ([61, Ericsson], [10, Nokia]) reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 1600 MHz bandwidth
	+ 2 sources ([64, OPPO], [10, Nokia]) reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 400 MHz bandwidth
	+ One source ([68, Huawei]) reported comparable performance of 240 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 400 MHz bandwidth
	+ One source ([26, Qualcomm]) evaluated and compared 120 KHz SCS with ICI compensation to larger SCS with CPE compensation. It reported that at MCSs 22 and 24, 120 kHz SCS with ICI compensation performs almost equal to 960 kHz SCS with CPE-only compensation in 400 MHz bandwidth.
	+ One source ([1, Futurewei]) reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in TDL-A 5 and 10ns as well as in CDL-D 30ns in 400 MHz bandwidth.
* At very high MCS (e.g., MCS 26 or MCS 28), three sources ([12, Intel], [26, Qualcomm], [69, Huawei]) compared ICI and CPE compensation using the Rel-15 PTRS.
	+ Note: the following references are used when derive the observations.
	+ One source ([12, Intel]) evaluated the phase noise compensation performance with MCS 28 when delay spread is not large. It is observed that de-ICI technique with 3-taps filter for smaller subcarrier spacing (240 kHz) fails even though there are sufficient number of PTRS tones available for ICI covariance construction.
	+ One source ([26, Qualcomm]) compared the performance of CPE and ICI compensation and reported for MCS 26, 120kHz SCS with ICI compensation suffers from residual ICI and is outperformed by 960kHz SCS with CPE-only compensation when delay spread is not large.
	+ One source ([68, Huawei]) showed that for MCS 28, de-ICI technique with large number of taps (11, 9 and 7 taps for 120, 240 and 480 kHz SCS respectively) outperforms 960 kHz with CPE compensation only when delay spread is not large. For normal CP, it also reported that 960 kHz with 3-tap ICI compensation has comparable performance to other SCS with larger number of taps (11, 9 and 7 taps for 120, 240 and 480 kHz SCS respectively) for MCS 28 when delay spread is not large. It also reported that with large delay spread (50ns in CDL), ECP and ICI compensation with at least 3 taps filter are needed for 960 kHz SCS to reach 1% BLER target for MCS 26.
* For high MCS (64QAM) with normal CP when delay spread is large (TDL-A with 40 ns and/or CDL-B with 50ns), 4 sources compared performance of smaller SCS (120, 240 and/or 480 kHz) with ICI compensation to that of 960 kHz SCS with CPE compensation and reported worse performance of 960 kHz SCS with CPE compensation for 10% BLER target.
	+ Note: the following are references used when derive the observations.
	+ One source ([61, Ericsson]) reported a performance gain of 5 dB in TDL-A 40ns and 0.3 dB in CDL-B 50ns for 480 kHz SCS with ICI compensation compared to 960 kHz SCS with CPE compensation in 1600 MHz bandwidth
	+ One source ([68, Huawei]) reported a performance gain of 2.6 dB (for 240 kHz SCS) and 1.6 dB (for 120 kHz SCS) in CDL-B 50ns with ICI compensation compared to 960 kHz SCS with CPE compensation
	+ One source ([64, OPPO]) reported a performance gain of 1 dB in CDL-B 50ns for 480 kHz SCS with ICI compensation compared to 960 kHz SCS with CPE compensation. It also reported the performance of 120 kHz with ICI compensation cannot meet the 10% BLER target.
	+ One source ([1, Futurewei]) reported the performance of 960 kHz SCS with CPE compensation cannot meet the 10% BLER target. It also reported that the performance of 480 kHz SCS with ICI compensation cannot meet the 10% BLER target in TDL-A 40ns. With ICI compensation, it also reported comparable performance of 120, 240 and 480 kHz SCS in CDL-B 50ns and comparable performance of 120 and 240 kHz SCS in TDL-A 40ns.
* Multiple sources evaluated and compared ICI compensation schemes using the existing Rel-15 NR distributed PTRS structure and/or new PTRS patterns. The results from different sources are not aligned on whether new PTRS patterns perform better than existing Rel-15 PTRS structure when ICI compensation is used.
	+ Note: the following are reference used when derive the observations.
	+ One source ([11, Mitsubishi]) evaluated with 120 and 240 kHz SCS and reported that the PN compensation with block-based PTRS and cyclic sequence significantly outperforms in spectral efficiency both CPE compensation and de-ICI Wiener filtering with distributed PTRS, even when the density of the scattered pattern is increased above the Rel.15 defined density.
	+ One source ([14, Ericsson]) reported that 3-tap direct de-ICI compensation with Rel-15 PTRS outperforms ICI filter approximation approach with clustered PTRS. 3-tap direct de-ICI compensation with a clustered PTRS structure does not offer any performance advantage over the existing Rel-15 NR distributed PTRS structure.
	+ One source ([23, MediaTek]) reported that with a 3-tap BLS ICI equalizer, a clustered PTRS structure does not offer any performance advantage over the existing Rel-15 NR distributed PTRS structure.
	+ One source ([62, LG]) reported that the performance of clustered PTRS allocation is worse than that of Rel-15 PTRS based ICI compensation scheme and further showed that the performance of subcarrier nulling allocation is similar or superior (up to 2 dB gain especially in the scenarios with low PTRS overhead, K=4) to that of Rel-15 PTRS based ICI compensation scheme.
	+ Two sources ([18, Samsung], [65, Apple]) evaluated the performance with some new PTRS patterns (e.g. chunk based PTRS pattern to allow adjacent PTRS symbols in frequency) and reported that the performance with ICI compensation based on new PTRS patterns is better than the Rel-15 pattern with CPE compensation only.
	+ One source ([26, Qualcomm]) reported that for the same ICI compensation algorithm, the legacy PTRS pattern outperforms the block PTRS pattern. It showed that for ICI compensation (direct de-ICI filtering) with the legacy PTRS pattern, the performance improves with the increasing number of de-ICI filter taps (3 to 5 taps). It also observed that with a fixed transport block size, the performance improves as the PTRS overhead decreases (the performance loss due to increased effective code rate is more pronounced at higher MCSs) and with a fixed effective code rate, the performance slightly improves as the PTRS overhead increases.
* For high MCS (64QAM) with normal CP, 2 sources ([61, Ericsson], [10, Nokia]) compared performance of 480 and 960 kHz SCS in 1600 MHz bandwidth when ICI compensation is used based on Rel-15 PTRS.
	+ When delay spread is not large, both sources reported a smaller than 1 dB performance gain of 960 kHz SCS for both 10% and 1% BLER target in TDL-A. One source ([61, Ericsson]) reported that for CDL-B, there is up to 1.1 dB gain at 1% BLER target for 960 kHz SCS.
	+ When delay spread is large (TDL-A with 40 ns DS), one source ([61, Ericsson]) reported 480 kHz SCS performed 3.6 dB better than 960 kHz SCS at 10% BLER target and 960 kHz SCS cannot meet the 1% BLER target.

### Agreement #53 (replace #33):

Summary observations #2a in Section 2.1.4 of R1-2009609 are agreed to supersede the previously agreed corresponding observations.

For CP-OFDM, the following are observed with respect to phase noise compensation and PTRS.

* Compared to no phase noise compensation, CPE compensation shows little gain at low and medium MCSs for all the evaluated SCS values; while significant gain is observed for high MCS (64QAM) for all the evaluated SCS values.
	+ Two sources ([57, InterDigital], [11, Mitsubishi])) reported that increased PTRS density in frequency domain based on Rel-15 configuration does not provide significant performance benefits.
* For a given SCS, the complexity of ICI compensation increases as the number of ICI filter tap increases
* For MCS 22 evaluation of the same SCS, performance gain of ICI compensation with additional complexity of multi-tap filtering compared to CPE-only compensation is observed when there is sufficient number of PTRS in the frequency domain for 120, 240 and 480 kHz SCS.
	+ Note: the following references are used when derive the observations.
	+ One source ([61, Ericsson]) showed performance gain of ICI compensation compared to CPE-only compensation for all evaluated SCS
	+ One source ([68, Huawei]) evaluated ICI compensation and compared with CPE-only compensation. It reported performance gain for all evaluated SCS.
	+ One source ([26, Qualcomm]) compared the performance of CPE and ICI compensation for 120 kHz SCS reported performance gain of ICI compensation.
	+ One source ([64, OPPO]) compared the performance of CPE and ICI compensation for all SCS. It reported performance gain of ICI compensation for 240 kHz and 480 kHz SCS. It reported performance gain of ICI compensation in CDL-B but a performance loss in TDL-A for 960 kHz SCS. It also reported that 120 kHz SCS still cannot meet 10% BLER target with ICI compensation.
	+ One source ([10, Nokia]) reported performance gain of ICI compensation for 120, 240 and 480 kHz SCS. It also reported performance gain of ICI compensation for 960 kHz SCS at 2GHz bandwidth and a performance loss of ICI compensation for 960 kHz SCS at 400MHz bandwidth.
	+ One source ([65, Apple]) evaluated ICI compensation for different SCS with a new PTRS pattern. It reported improvement of ICI compensation compared to CPE-only compensation.
	+ One source ([18, Samsung]) evaluated 120 kHz and 240 kHz SCS performance with ICI compensation based on some new PTRS pattern and reported performance improvement.
	+ One source ([1, Futurewei]) compared ICI performance among SCS. It reported performance gain of multi-tap ICI filter over CPE compensation for 120, 240 and 480 kHz SCS
	+ One source ([12, Intel]) evaluated performance of de-ICI method for MCS 22 with small RB allocations for 240, 480 and 960 KHz SCS. It is observed that the de-ICI method do not work when there isn’t sufficient number of PTRS tones in the frequency domain.
	+ One source ([15, LG]) compared the performance of CPE and ICI compensation for all SCS. It reported performance gain of ICI compensation for 120 kHz and 240 kHz SCS.
* For MCS 22 with normal CP when delay spread is not large, it is observed that ICI compensation of multi-tap filtering is required for 120, 240 and/or 480 kHz SCS to achieve comparable performance (< 1 dB difference) to that of 960 kHz SCS with CPE-only compensation for 10% BLER target
	+ Note: the following references are used when derive the observations.
	+ 2 sources ([61, Ericsson], [10, Nokia]) reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 1600 MHz bandwidth
	+ 3 sources ([64, OPPO], [10, Nokia], [15, LG]) reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 400 MHz bandwidth
	+ One source ([68, Huawei]) reported comparable performance of 240 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 400 MHz bandwidth
	+ One source ([26, Qualcomm]) evaluated and compared 120 KHz SCS with ICI compensation to larger SCS with CPE compensation. It reported that at MCSs 22 and 24, 120 kHz SCS with ICI compensation performs almost equal to 960 kHz SCS with CPE-only compensation in 400 MHz bandwidth.
	+ One source ([1, Futurewei]) reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in TDL-A 5 and 10ns as well as in CDL-D 30ns in 400 MHz bandwidth.
* At very high MCS (e.g., MCS 26 or MCS 28), 4 sources ([12, Intel], [26, Qualcomm], [68, Huawei], [15, LG]) compared ICI and CPE compensation using the Rel-15 PTRS.
	+ Note: the following references are used when derive the observations.
	+ One source ([12, Intel]) evaluated the phase noise compensation performance with MCS 28 when delay spread is not large. It is observed that de-ICI technique with 3-taps filter for smaller subcarrier spacing (240 kHz) fails even though there are sufficient number of PTRS tones available for ICI covariance construction.
	+ One source ([26, Qualcomm]) compared the performance of CPE and ICI compensation and reported for MCS 26, 120kHz SCS with ICI compensation suffers from residual ICI and is outperformed by 960kHz SCS with CPE-only compensation when delay spread is not large.
	+ One source ([68, Huawei]) showed that for MCS 28, de-ICI technique with large number of taps (11, 9 and 7 taps for 120, 240 and 480 kHz SCS respectively) outperforms 960 kHz with CPE compensation only when delay spread is not large. For normal CP, it also reported that 960 kHz with 3-tap ICI compensation has comparable performance to other SCS with larger number of taps (11, 9 and 7 taps for 120, 240 and 480 kHz SCS respectively) for MCS 28 when delay spread is not large. It also reported that with large delay spread (50ns in CDL), ECP and ICI compensation with at least 3 taps filter are needed for 960 kHz SCS to reach 1% BLER target for MCS 26.
	+ One source ([15, LG]) evaluated 3-tap ICI and CPE compensation for MCS 26 at 10ns in TDL-A for all SCS with normal CP. It reported 960 kHz SCS with CPE-only compensation outperforms both 240 kHz and 480 kHz SCS with ICI compensation. It also reported that 120 kHz SCS with ICI compensation cannot meet 10% BLER target.
* For high MCS (64QAM) with normal CP when delay spread is large (TDL-A with 40 ns and/or CDL-B with 50ns), 4 sources compared performance of smaller SCS (120, 240 and/or 480 kHz) with ICI compensation to that of 960 kHz SCS with CPE compensation and reported worse performance of 960 kHz SCS with CPE compensation for 10% BLER target.
	+ Note: the following are references used when derive the observations.
	+ One source ([61, Ericsson]) reported a performance gain of 5 dB in TDL-A 40ns and 0.3 dB in CDL-B 50ns for 480 kHz SCS with ICI compensation compared to 960 kHz SCS with CPE compensation in 1600 MHz bandwidth
	+ One source ([68, Huawei]) reported a performance gain of 2.6 dB (for 240 kHz SCS) and 1.6 dB (for 120 kHz SCS) in CDL-B 50ns with ICI compensation compared to 960 kHz SCS with CPE compensation
	+ One source ([64, OPPO]) reported a performance gain of 1 dB in CDL-B 50ns for 480 kHz SCS with ICI compensation compared to 960 kHz SCS with CPE compensation. It also reported the performance of 120 kHz with ICI compensation cannot meet the 10% BLER target.
	+ One source ([1, Futurewei]) reported the performance of 960 kHz SCS with CPE compensation cannot meet the 10% BLER target. It also reported that the performance of 480 kHz SCS with ICI compensation cannot meet the 10% BLER target in TDL-A 40ns. With ICI compensation, it also reported comparable performance of 120, 240 and 480 kHz SCS in CDL-B 50ns and comparable performance of 120 and 240 kHz SCS in TDL-A 40ns.
* Multiple sources evaluated and compared ICI compensation schemes using the existing Rel-15 NR distributed PTRS structure and/or new PTRS patterns. The results from different sources are not aligned on whether new PTRS patterns perform better than existing Rel-15 PTRS structure when ICI compensation is used.
	+ Note: the following are reference used when derive the observations.
	+ One source ([11, Mitsubishi]) evaluated with 120 and 240 kHz SCS and reported that the PN compensation with block-based PTRS and cyclic sequence significantly outperforms in spectral efficiency both CPE compensation and de-ICI Wiener filtering with distributed PTRS, even when the density of the scattered pattern is increased above the Rel.15 defined density.
	+ One source ([14, Ericsson]) reported that 3-tap direct de-ICI compensation with Rel-15 PTRS outperforms ICI filter approximation approach with clustered PTRS. 3-tap direct de-ICI compensation with a clustered PTRS structure does not offer any performance advantage over the existing Rel-15 NR distributed PTRS structure.
	+ One source ([23, MediaTek]) reported that with a 3-tap BLS ICI equalizer, a clustered PTRS structure does not offer any performance advantage over the existing Rel-15 NR distributed PTRS structure.
	+ One source ([62, LG]) reported that the performance of clustered PTRS allocation is worse than that of Rel-15 PTRS based ICI compensation scheme and further showed that the performance of subcarrier nulling allocation is similar or superior (up to 2 dB gain especially in the scenarios with low PTRS overhead, K=4) to that of Rel-15 PTRS based ICI compensation scheme.
	+ Two sources ([18, Samsung], [65, Apple]) evaluated the performance with some new PTRS patterns (e.g. chunk based PTRS pattern to allow adjacent PTRS symbols in frequency) and reported that the performance with ICI compensation based on new PTRS patterns is better than the Rel-15 pattern with CPE compensation only.
	+ One source ([26, Qualcomm]) reported that for the same ICI compensation algorithm, the legacy PTRS pattern outperforms the block PTRS pattern. It showed that for ICI compensation (direct de-ICI filtering) with the legacy PTRS pattern, the performance improves with the increasing number of de-ICI filter taps (3 to 5 taps). It also observed that with a fixed transport block size, the performance improves as the PTRS overhead decreases (the performance loss due to increased effective code rate is more pronounced at higher MCSs) and with a fixed effective code rate, the performance slightly improves as the PTRS overhead increases.
	+ One source ([68, Huawei]) compared BLER performance and spectrum efficiency of 120 kHz SCS with Rel-15 PTRS and block PTRS in CDL-B/D 20ns delay spread for MCS 22. It reported a slight BLER performance gain (~ 0.5 dB) and spectrum efficiency gain (2% - 6%) of block PTRS for 10% BLER target when a sequence which has constant module in both time domain and frequency domain is used with block PTRS.
* For high MCS (64QAM) with normal CP, 2 sources ([61, Ericsson], [10, Nokia]) compared performance of 480 and 960 kHz SCS in 1600 MHz bandwidth when ICI compensation is used based on Rel-15 PTRS.
	+ When delay spread is not large, both sources reported a smaller than 1 dB performance gain of 960 kHz SCS for both 10% and 1% BLER target in TDL-A. One source ([61, Ericsson]) reported that for CDL-B, there is up to 1.1 dB gain at 1% BLER target for 960 kHz SCS.
	+ When delay spread is large (TDL-A with 40 ns DS), one source ([61, Ericsson]) reported 480 kHz SCS performed 3.6 dB better than 960 kHz SCS at 10% BLER target and 960 kHz SCS cannot meet the 1% BLER target.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.1**

For CP-OFDM, the following are observed with respect to phase noise compensation and PTRS. * Compared to no phase noise compensation, CPE compensation shows little gain at low and medium MCSs for all the evaluated SCS values; while significant gain is observed for high MCS (64QAM) for all the evaluated SCS values.
	+ Two sources, [61], and [15], reported that increased PTRS density in frequency domain based on Rel-15 configuration does not provide significant performance benefits.
* For a given SCS, the complexity of ICI compensation increases as the number of ICI filter tap increases
* For MCS 22 evaluation of the same SCS, performance gain of ICI compensation with additional complexity of multi-tap filtering compared to CPE-only compensation is observed when there is sufficient number of PTRS in the frequency domain for 120, 240 and 480 kHz SCS.
	+ One source [65] showed performance gain of ICI compensation compared to CPE-only compensation for all evaluated SCS
	+ One source [72] evaluated ICI compensation and compared with CPE-only compensation. It reported performance gain for all evaluated SCS.
	+ One source [30] compared the performance of CPE and ICI compensation for 120 kHz SCS reported performance gain of ICI compensation.
	+ One source [68] compared the performance of CPE and ICI compensation for all SCS. It reported performance gain of ICI compensation for 240 kHz and 480 kHz SCS. It reported performance gain of ICI compensation in CDL-B but a performance loss in TDL-A for 960 kHz SCS. It also reported that 120 kHz SCS still cannot meet 10% BLER target with ICI compensation.
	+ One source [14] reported performance gain of ICI compensation for 120, 240 and 480 kHz SCS. It also reported performance gain of ICI compensation for 960 kHz SCS at 2GHz bandwidth and a performance loss of ICI compensation for 960 kHz SCS at 400MHz bandwidth.
	+ One source [69] evaluated ICI compensation for different SCS with a new PTRS pattern. It reported improvement of ICI compensation compared to CPE-only compensation.
	+ One source [22] evaluated 120 kHz and 240 kHz SCS performance with ICI compensation based on some new PTRS pattern and reported performance improvement.
	+ One source [5] compared ICI performance among SCS. It reported performance gain of multi-tap ICI filter over CPE compensation for 120, 240 and 480 kHz SCS
	+ One source [16] evaluated performance of de-ICI method for MCS 22 with small RB allocations for 240, 480 and 960 KHz SCS. It is observed that the de-ICI method do not work when there isn’t sufficient number of PTRS tones in the frequency domain.
	+ One source [19] compared the performance of CPE and ICI compensation for all SCS. It reported performance gain of ICI compensation for 120 kHz and 240 kHz SCS.
* For MCS 22 with normal CP when delay spread is not large, it is observed that ICI compensation of multi-tap filtering is required for 120, 240 and/or 480 kHz SCS to achieve comparable performance (< 1 dB difference) to that of 960 kHz SCS with CPE-only compensation for 10% BLER target
	+ 2 sources, [65], and [14], reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 1600 MHz bandwidth
	+ 3 sources, [68], [14], and [19], reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 400 MHz bandwidth
	+ One source [72] reported comparable performance of 240 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in 400 MHz bandwidth
	+ One source [30] evaluated and compared 120 KHz SCS with ICI compensation to larger SCS with CPE compensation. It reported that at MCSs 22 and 24, 120 kHz SCS with ICI compensation performs almost equal to 960 kHz SCS with CPE-only compensation in 400 MHz bandwidth.
	+ One source [5] reported comparable performance of 480 kHz SCS with ICI compensation and 960 kHz SCS with CPE compensation in TDL-A 5 and 10ns as well as in CDL-D 30ns in 400 MHz bandwidth.
* At very high MCS (e.g., MCS 26 or MCS 28), 4 sources, [16], [30], [72], and [19], compared ICI and CPE compensation using the Rel-15 PTRS.
	+ One source [16] evaluated the phase noise compensation performance with MCS 28 when delay spread is not large. It is observed that de-ICI technique with 3-taps filter for smaller subcarrier spacing (240 kHz) fails even though there are sufficient number of PTRS tones available for ICI covariance construction.
	+ One source [30], compared the performance of CPE and ICI compensation and reported for MCS 26, 120kHz SCS with ICI compensation suffers from residual ICI and is outperformed by 960kHz SCS with CPE-only compensation when delay spread is not large.
	+ One source [72] showed that for MCS 28, de-ICI technique with large number of taps (11, 9 and 7 taps for 120, 240 and 480 kHz SCS respectively) outperforms 960 kHz with CPE compensation only when delay spread is not large. For normal CP, it also reported that 960 kHz with 3-tap ICI compensation has comparable performance to other SCS with larger number of taps (11, 9 and 7 taps for 120, 240 and 480 kHz SCS respectively) for MCS 28 when delay spread is not large. It also reported that with large delay spread (50ns in CDL), ECP and ICI compensation with at least 3 taps filter are needed for 960 kHz SCS to reach 1% BLER target for MCS 26.
	+ One source [19] evaluated 3-tap ICI and CPE compensation for MCS 26 at 10ns in TDL-A for all SCS with normal CP. It reported 960 kHz SCS with CPE-only compensation outperforms both 240 kHz and 480 kHz SCS with ICI compensation. It also reported that 120 kHz SCS with ICI compensation cannot meet 10% BLER target.
* For high MCS (64QAM) with normal CP when delay spread is large (TDL-A with 40 ns and/or CDL-B with 50ns), 4 sources compared performance of smaller SCS (120, 240 and/or 480 kHz) with ICI compensation to that of 960 kHz SCS with CPE compensation and reported worse performance of 960 kHz SCS with CPE compensation for 10% BLER target.
	+ One source [65] reported a performance gain of 5 dB in TDL-A 40ns and 0.3 dB in CDL-B 50ns for 480 kHz SCS with ICI compensation compared to 960 kHz SCS with CPE compensation in 1600 MHz bandwidth
	+ One source [72] reported a performance gain of 2.6 dB (for 240 kHz SCS) and 1.6 dB (for 120 kHz SCS) in CDL-B 50ns with ICI compensation compared to 960 kHz SCS with CPE compensation
	+ One source [68] reported a performance gain of 1 dB in CDL-B 50ns for 480 kHz SCS with ICI compensation compared to 960 kHz SCS with CPE compensation. It also reported the performance of 120 kHz with ICI compensation cannot meet the 10% BLER target.
	+ One source [5] reported the performance of 960 kHz SCS with CPE compensation cannot meet the 10% BLER target. It also reported that the performance of 480 kHz SCS with ICI compensation cannot meet the 10% BLER target in TDL-A 40ns. With ICI compensation, it also reported comparable performance of 120, 240 and 480 kHz SCS in CDL-B 50ns and comparable performance of 120 and 240 kHz SCS in TDL-A 40ns.
* Multiple sources evaluated and compared ICI compensation schemes using the existing Rel-15 NR distributed PTRS structure and/or new PTRS patterns. The results from different sources are not aligned on whether new PTRS patterns perform better than existing Rel-15 PTRS structure when ICI compensation is used.
	+ One source [15] evaluated with 120 and 240 kHz SCS and reported that the PN compensation with block-based PTRS and cyclic sequence significantly outperforms in spectral efficiency both CPE compensation and de-ICI Wiener filtering with distributed PTRS, even when the density of the scattered pattern is increased above the Rel.15 defined density.
	+ One source [18] reported that 3-tap direct de-ICI compensation with Rel-15 PTRS outperforms ICI filter approximation approach with clustered PTRS. 3-tap direct de-ICI compensation with a clustered PTRS structure does not offer any performance advantage over the existing Rel-15 NR distributed PTRS structure.
	+ One source [27] reported that with a 3-tap BLS ICI equalizer, a clustered PTRS structure does not offer any performance advantage over the existing Rel-15 NR distributed PTRS structure.
	+ One source [66] reported that the performance of clustered PTRS allocation is worse than that of Rel-15 PTRS based ICI compensation scheme and further showed that the performance of subcarrier nulling allocation is similar or superior (up to 2 dB gain especially in the scenarios with low PTRS overhead, K=4) to that of Rel-15 PTRS based ICI compensation scheme.
	+ Two sources, [22], and [69], evaluated the performance with some new PTRS patterns (e.g. chunk based PTRS pattern to allow adjacent PTRS symbols in frequency) and reported that the performance with ICI compensation based on new PTRS patterns is better than the Rel-15 pattern with CPE compensation only.
	+ One source [30] reported that for the same ICI compensation algorithm, the legacy PTRS pattern outperforms the block PTRS pattern. It showed that for ICI compensation (direct de-ICI filtering) with the legacy PTRS pattern, the performance improves with the increasing number of de-ICI filter taps (3 to 5 taps). It also observed that with a fixed transport block size, the performance improves as the PTRS overhead decreases (the performance loss due to increased effective code rate is more pronounced at higher MCSs) and with a fixed effective code rate, the performance slightly improves as the PTRS overhead increases.
	+ One source [72] compared BLER performance and spectrum efficiency of 120 kHz subcarrier spacing with Rel-15 PTRS and block PTRS in CDL-B/D 20ns delay spread for MCS 22. It reported a slight BLER performance gain (~ 0.5 dB) and spectrum efficiency gain (2% - 6%) of block PTRS for 10% BLER target when a sequence which has constant module in both time domain and frequency domain is used with block PTRS.
* For high MCS (64QAM) with normal CP, 2 sources, [65], and [14], compared performance of 480 and 960 kHz SCS in 1600 MHz bandwidth when ICI compensation is used based on Rel-15 PTRS.
	+ When delay spread is not large, both sources reported a smaller than 1 dB performance gain of 960 kHz SCS for both 10% and 1% BLER target in TDL-A. One source, [65], reported that for CDL-B, there is up to 1.1 dB gain at 1% BLER target for 960 kHz SCS.
	+ When delay spread is large (TDL-A with 40 ns DS), one source, [65], reported 480 kHz SCS performed 3.6 dB better than 960 kHz SCS at 10% BLER target and 960 kHz SCS cannot meet the 1% BLER target.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |
| vivo | Section 6.1.1, “At very high MCS (e.g., MCS 26 or MCS 28), three sources, [16], [30], and [73], compared ICI and CPE compensation using the Rel-15 PTRS.” should be “At very high MCS (e.g., MCS 26 or MCS 28), 4 sources, [16], [30], [72] and [19], compared ICI and CPE compensation using the Rel-15 PTRS.” |
| Moderator | Updated as corrected by vivo. |
| Huawei | “At very high MCS (e.g., MCS 26 or MCS 28), 4 sources, [16], [30], [73], and [19], compared ICI and CPE compensation using the Rel-15 PTRS.” Typo in the reference [73]  [72] |
| Moderator | Corrected typo as suggested by Huawei. |

### Agreement #34:

Capture the following observations in the TR (updates to references and other editorial modifications can be made for inclusion in the TR):

For CP-OFDM, two sources ([14, 61, Ericsson], [68, Huawei]) evaluated PDSCH BLER performance with optional PN models in addition to PN model in Table A.1-1 of TR 38.808. Note that such optional PN models are not confirmed and/or recommended by RAN4 at the time of RAN1#103-e (These observations can be updated if RAN4 input is available).

* When CPE-only compensation is used with an optional PN model at the UE or at BS and UE, it is observed by both sources that there is significantly less dependence of BLER performance on SCS compared to the PN model in Table A.1-1 of TR 38.808. For all test cases, no error floor is observed for smaller SCS with TDL-A or CDL-B/CDL-D for 1% BLER target. There is around 1 to 2 dB performance difference between consecutive SCSs for 1% BLER target.
* However, multiple sources expressed concerns on the validity of such optional PN models given no confirmation and/or recommendation from RAN4. In consequence, there’s a concern on whether and how the observations based on such optional PN models can be used given no RAN4 input on these optional PN models.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.1.1**

For CP-OFDM, two sources, [65], and [72], evaluated PDSCH BLER performance with optional PN models in addition to PN model in Table A.1-1. Note that such optional PN models are not confirmed and/or recommended by RAN4 at the time of RAN1#103-e.* When CPE-only compensation is used with an optional PN model at the UE or at BS and UE, it is observed by both sources that there is significantly less dependence of BLER performance on SCS compared to the PN model in Table A.1-1. For all test cases, no error floor is observed for smaller SCS with TDL-A or CDL-B/CDL-D for 1% BLER target. There is around 1 to 2 dB performance difference between consecutive SCSs for 1% BLER target.
* However, multiple sources expressed concerns on the validity of such optional PN models given no confirmation and/or recommendation from RAN4. In consequence, there’s a concern on whether and how the observations based on such optional PN models can be used given no RAN4 input on these optional PN models.
 |
|  **Company** | **Comments** |
| Ericsson | Agree to capture "as is" |

### Agreement #35:

* Update BS Antenna Pattern in Table A.2-1 of TR 38.808 as the following.

|  |  |
| --- | --- |
| BS Antenna Pattern | For outdoor scenarios:- Antenna power pattern given in Table 7.3-1 of TR38.901(with exception of antenna element gain)For indoor~~/factory~~ scenarios:- Antenna power pattern given in Table A.2.1-7 of TR38.802 for ceiling mount(with exception of antenna element gain)For factory scenarios:Companies to provide information on the antenna orientation and pattern used. |

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Update Annex A.2 based on agreement.**
 |
|  **Company** | **Comments** |
| Ericsson | Agree with moderator's proposal |

### Agreement #36:

* Update the indoor A description as follows:

Office box 120m x 50 m, 12 BS per operator, 2 operator, BS height at 3m (ceiling), UE height 1m, x-axis ISD = 20m and y-axis ISD = 25m, where ISD is define by the distance between two adjacent 10m x 10m virtual box, BS randomly deployed within 10m x 10m virtual box, minimum distance between BS of different operators is 2m.”



|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Update Annex A.2 based on agreement.**
 |
|  **Company** | **Comments** |
| Ericsson | Agree with moderator's proposal |

### Agreement #37:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

The following discussion refers to 5th percentile users as ‘tail’ users and 95th percentile users as ‘upper-tail’ users. Remarks mentioning ‘all users’ are applicable to tail, median and upper tail users at once.

* Comparison of No-LBT with directional LBT (TxED-Dir) for Indoor Scenario A: Vivo, Huawei, Nokia, Samsung, Intel, Ericsson provided results
* Vivo results show gain for directional LBT ((TxED-Dir) over No-LBT for DL, high load, for tail , median and upper tail users, and for UL, high load for tail users. For all other cases in this comparison, TxED-Dir underperforms No-LBT. (EDT -47 dBm)
* Nokia, for 100% DL presented low, medium and high load results. For all loads, their results show significant loss for both directional and omni-directional LBT for median and high-end users. Only the tail users may have some benefit from directional LBT (as compared to No-LBT), while omni-LBT provides loss also in this case (EDT -48 dBm).
* Ericsson results show No-LBT outperforms directional LBT with (EDT -47 dBm) and directional LBT with (ED -32 dBm for gNB, ED -41 dBm for UE)
* Samsung results show gain in medium and high loads for directional LBT over No-LBT at (EDT -47 dBm) for all users for DL as well as for UL. At low loads TxED-Dir underperforms No-LBT.
* Intel shows gains for DL throughput at high loads with TxED-Dir LBT for all antenna configurations when BSs are ceiling mounted, and gains for 5%ile DL throughput at high loads when the BS are not ceiling mounted. In other cases including all loads for UL, TdxED-Dir LBT scheme shows losses. All results are at ED threshold of -48
* Huawei largely shows loss for directional LBT over No-LBT for all loading levels and users, except DL, tail users at high loading where the results are comparable. Huawei’s TxED-Dir uses CW-Max of 127 with EDT of -47 dBm.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.2**
* For comparison of No-LBT with directional LBT (TxED-Dir) for Indoor Scenario A, 6 sources, [37], [72], [62], [67], [43], and [65], provided results and the following are observations from the evaluations:
* Results from source [37] show gain for directional LBT (TxED-Dir with EDT -47 dBm) over No-LBT for DL, high load, for tail, median and upper tail users, and for UL, high load for tail users. For all other cases in this comparison, TxED-Dir underperforms No-LBT.
* Results from source [62], provided evaluations for 100% DL presented low, medium and high load results. For all loads, their results show significant loss for both directional and omni-directional LBT for median and high-end users. Only the tail users may have some benefit from directional LBT (as compared to No-LBT), while omni-LBT provides loss also in this case (EDT -48 dBm).
* Results from source [65] show No-LBT outperforms directional LBT with EDT -47 dBm and directional LBT with ED -32 dBm for gNB, ED -41 dBm for UE.
* Results from [67] show gain in medium and high loads for directional LBT over No-LBT at EDT -47 dBm for all users for DL as well as for UL. At low loads TxED-Dir underperforms No-LBT.
* Results from source [43] shows gains for DL throughput at high loads with TxED-Dir LBT for all antenna configurations when BSs are ceiling mounted, and gains for 5%ile DL throughput at high loads when the BS are not ceiling mounted. In other cases, including all loads for UL, TxED-Dir LBT scheme shows losses. All results are at ED threshold of -48 dBm.
* Results from source [72] largely shows loss for directional LBT over No-LBT for all loading levels and users, except DL, tail users at high loading where the results are comparable. Results were based on TxED-Dir with CW-Max of 127 with EDT of -47 dBm.
 |
|  **Company** | **Comments** |
| Huawei/HiSilicon3 | We suggest that the following part of the agreement be included in Section 6.2 of TR as it applies to all Observations in Sections 6.2.2 to 6.2.6 of TR.“The following discussion refers to 5th percentile users as ‘tail’ users and 95th percentile users as ‘upper-tail’ users. Remarks mentioning ‘all users’ are applicable to tail, median and upper tail users at once.” |
|  |  |

### Agreement #38:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

* Comparison of Omni LBT (TxED-Omni) with directional LBT (TxED-Dir) for Indoor Scenario A: Vivo, ZTE, Nokia, Samsung, Intel, Qualcomm, Ericsson, and Huawei, provided results
* For Omni LBT (TxED-Omni) with directional LBT (TxED-Dir) have been done with using the same ED Threshold. Additionally, Ericsson simulated directional LBT with adjusted thresholds (ED -32 dBm for gNB, ED -41 dBm for UE). Multiple companies have evaluated adjustments to ED Threshold with directional sensing either implicitly or explicitly.
* Vivo results show that omni-directional is better than directional LBT in tail and median performance, and marginal difference in other cases. Both omni-directional and directional LBT use the same ED threshold of -47 dBm
* Samsung shows gain at all loading levels for directional LBT over omni-LBT (-47 dBm) for all users, for DL and UL traffic.
* Intel shows that for UL TxED-Dir LBT provides better performance relative to TxED-Omni for low ED thresholds (i.e., -55 and -65 dBm) but losses for high thresholds (i.e., -48 dBm). As for DL, TxED-Dir LBT provides consistently better performances than TxED-Omni. The gain of directionality increases with more directional UE beams.
* Qualcomm results show largely a comparable performance for omni and directional sensing using equal threshold, with small benefit of directionality under gNBs with narrower beams
* Ericsson results show that directional LBT with adjusted thresholds (ED -32 dBm for gNB, ED -41 dBm for UE) and directional LBT with ED -47 dBm, and omni-directional LBT with ED -47 dBm have comparable performance.
* For 100% DL traffic, Nokia results show that directional LBT TxED-Dir outperforms TxED-Omni at low as well as medium loads – for median, tail as well as upper tail users. The results use EDT -48~~7~~ dBm
* For 100% DL traffic, ZTE shows gains in directional LBT for tail usersand median users at ED threshold~~s~~ -68 dBm and -62 dBm. The gains are also present in DL+UL Traffic at ED threshold -68 dBm and -62 dBm.
* Coexistence: ZTE shows that an operator using directional LBT benefits in the presence of an operator using Omni LBT, relative to a deployment where both operators use Omni-LBT. The results use ED threshold -68 dBm.
* Huawei’s results show that directional LBT (TxED-Dir) does not outperform Omni LBT (TxED-Omni)

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.2**
* For comparison of Omni LBT (TxED-Omni) with directional LBT (TxED-Dir) for Indoor Scenario A, 8 sources, [37], [64], [62], [67], [43], [56], [65], and [72], provided results and the following are observations from the evaluations:
* For Omni LBT (TxED-Omni) with directional LBT (TxED-Dir) have been done with using the same ED Threshold. Additionally, source [65] evaluated directional LBT with adjusted thresholds ED -32 dBm for gNB, and ED -41 dBm for UE. Multiple companies have evaluated adjustments to ED Threshold with directional sensing either implicitly or explicitly.
* Results from source [37] show that omni-directional is better than directional LBT in tail and median performance, and marginal difference in other cases. Both omni-directional and directional LBT use the same ED threshold of -47 dBm.
* Results from source [67] shows gain at all loading levels for directional LBT over omni-LBT (-47 dBm) for all users, for DL and UL traffic.
* Results from source [43] shows that for UL TxED-Dir LBT provides better performance relative to TxED-Omni for low ED thresholds (i.e., -55 and -65 dBm) but losses for high thresholds (i.e., -48 dBm). As for DL, TxED-Dir LBT provides consistently better performances than TxED-Omni. The gain of directionality increases with more directional UE beams.
* Results from source [56] show largely a comparable performance for omni and directional sensing using equal threshold, with small benefit of directionality under gNBs with narrower beams.
* Results from source [65] show that directional LBT with adjusted thresholds (ED -32 dBm for gNB, ED -41 dBm for UE) and directional LBT with ED -47 dBm, and omni-directional LBT with ED -47 dBm have comparable performance.
* For 100% DL traffic, results from source [62] show that directional LBT TxED-Dir outperforms TxED-Omni at low as well as medium loads – for median, tail as well as upper tail users. The results use EDT -48 dBm.
* For 100% DL traffic, results from source [64] shows gains in directional LBT for tail usersand median users at ED threshold~~s~~ -68 dBm and -62 dBm. The gains are also present in DL+UL Traffic at ED threshold -68 dBm and -62 dBm.
* For coexistence, results from source [64]shows that an operator using directional LBT benefits in the presence of an operator using Omni LBT, relative to a deployment where both operators use Omni-LBT. The results used ED threshold of -68 dBm.
* Results from source [72] show that directional LBT (TxED-Dir) does not outperform Omni LBT (TxED-Omni).
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #39:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

* Comparison of No-LBT with receiver assisted LBT for Indoor Scenario A: Ericsson, Huawei, Vivo, provided results
* Different versions of receiver assistance modelled as presented earlier
* Ericsson results uses omni-sensing at receiver. The results do not show benefit for receiver assistance over No-LBT.
* Vivo’s results use an EDT -47 dBm, in the results, RxA-4-Omni gains in both DL and UL relative to No-LBT for tail users at high loads. RxA-4-Omni gains in DL but loses in UL relative to No-LBT for medium and high loads at all other user percentiles and mean.
* Huawei’s Receiver-only LBT (RxA-3) shows tail UPT and mean UPT gain compared to No-LBT in low, medium, and high traffic loads with InH Open Office channel model 40] and InH mixed channel model [40] in both UL and DL.
* In comparison with No-LBT, Huawei shows Receiver-assisted LBT (RxA-2) Tail UPT gain in DL with high traffic load for InH open office channel model and loss in other cases. Also, Huawei shows Receiver-assisted LBT Tail UPT gain in DL with low, moderate and high traffic load for InH mixed channel model and loss in other cases.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.2**
* For comparison of No-LBT with receiver assisted LBT for Indoor Scenario A, 3 sources, [65], [72], and [37], provided results and the following are observations from the evaluations:
* Description of the different versions of receiver assistance modelled are provided section X.X.X.
* Results from source [65] uses omni-sensing at receiver. The results do not show benefit for receiver assistance over No-LBT.
* Results from source [37] use an EDT -47 dBm and in the results, RxA-4-Omni gains in both DL and UL relative to No-LBT for tail users at high loads. RxA-4-Omni gains in DL but loses in UL relative to No-LBT for medium and high loads at all other user percentiles and mean.
* Results from source [72], the receiver-only LBT (RxA-3) shows tail UPT and mean UPT gain compared to No-LBT in low, medium, and high traffic loads with InH Open Office channel model and InH mixed channel model in both UL and DL.
* In comparison with No-LBT, results from source [72] shows Receiver-assisted LBT (RxA-2) tail UPT gain in DL with high traffic load for InH open office channel model and loss in other cases. Also, the results show Receiver-assisted LBT Tail UPT gain in DL with low, moderate and high traffic load for InH mixed channel model and loss in other cases.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #40:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

* Comparison of receiver assisted LBT versions with Omni LBT (Tx-ED-omni), and directional LBT (TxED-dir) for Indoor Scenario A: Huawei, Qualcomm, Vivo and Ericsson provided results
* Ericsson results show similar performance of receiver assisted LBT (RxA-1) and omni- directional LBT (TxED-Omni). Nonetheless, the RxA-1 implementation does not model the overhead of information exchange between the transmitter and receiver. Hence, it is expected that the actual performance of RxA-1 is worse than the simulated one
* Huawei’s both flavors of receiver assistance, Rx-Assisted LBT (RxA-2), and Receiver Only LBT (RxA-3) outperform Tx-ED-Omi and Tx-ED-Dir at all loading levels and users percentiles, with larger benefits to tail users
* Qualcomm results show gains with receiver assisted LBT for DL and UL in the median as well as tail, primarily at higher loading levels. (A) The results show receiver assisted LBT RxA-5 Omni @EDT -67dBm and RxA-5 Dir@-67dBm 67dBm outperforms TxED-Omni and TxED-Dir as loading level increases. (B) Qualcomm results show comparable performance of RxA-5 Omni and RxA-5 Dir for the baseline gNB Antenna Configuration. (C) Further, as directionality increases at the gNB with more antenna elements, ( i.e. when gNB Configuration (Mg,Ng,M,N,P) = (1,1,4,8,2) is replaced with (Mg,Ng,M,N,P) = (1,1,8,16,2)) the relative benefits of Rx-Assistance are shown to be larger,. (D) Further as silencing Threshold is decreased from -67 to -72 dBm, the relative gains of Rx-Assistance increase. At 2 gHz BW, a silencing threshold of -72dBm is close to noise floor and may not be achieved as ED but may require a sequence detection mechanism.
* Vivo results show gains with receiver assisted LBT RxA-4-Omni relative to TxED-Omni primarily for uplink, at medium and high loads for all users. For DL, the performance is comparable between RxA-4 Omni and TxED-Omni, except at high load tail, where RxA-4-Omni underperforms.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.2**
* For comparison of receiver assisted LBT versions with Omni LBT (Tx-ED-omni), and directional LBT (TxED-dir) for Indoor Scenario A, 4 sources, [72], [56], [37], and [65], provided results and the following are observations from the evaluations:
* Results from [65] show similar performance of receiver assisted LBT (RxA-1) and omni- directional LBT (TxED-Omni). Nonetheless, the RxA-1 implementation does not model the overhead of information exchange between the transmitter and receiver. Hence, it is expected that the actual performance of RxA-1 is worse than the simulated one.
* Results from [72] show both flavors of receiver assistance, Rx-Assisted LBT (RxA-2), and Receiver Only LBT (RxA-3), and it outperforms Tx-ED-Omi and Tx-ED-Dir at all loading levels and users percentiles with larger benefits to tail users.
* Results from [56] show gains with receiver assisted LBT for DL and UL in the median as well as tail, primarily at higher loading levels.
	+ The results show receiver assisted LBT RxA-5 Omni with EDT -67 dBm and RxA-5 Dir with -67 dBm. Results with -67 dBm outperforms TxED-Omni and TxED-Dir as loading level increases.
	+ The results show comparable performance of RxA-5 Omni and RxA-5 Dir for the baseline gNB antenna configuration.
	+ As directionality increases at the gNB with more antenna elements, (i.e. when gNB configuration (Mg,Ng,M,N,P) = (1,1,4,8,2) is replaced with (Mg,Ng,M,N,P) = (1,1,8,16,2)), the relative benefits of Rx-Assistance are shown to be larger.
	+ As silencing threshold is decreased from -67 to -72 dBm, the relative gains of Rx-Assistance increase. At 2 GHz bandwidth, a silencing threshold of -72 dBm is close to noise floor and may not be achieved as ED but may require a sequence detection mechanism.
* Results from [37] show gains with receiver assisted LBT RxA-4-Omni relative to TxED-Omni primarily for uplink, at medium and high loads for all users. For DL, the performance is comparable between RxA-4 Omni and TxED-Omni, except at high load tail, where RxA-4-Omni underperforms.
 |
|  **Company** | **Comments** |
| Huawei/HiSilicon3 | Please make the following editorial change as both RxA-2 and RxA-3 outperform Tx-ED-Omi and Tx-ED-Dir. Also, change Tx-ED-Omi to Tx-ED-Omni.* Results from [72] show both flavors of receiver assistance, Rx-Assisted LBT (RxA-2), and Receiver Only LBT (RxA-3), and they outperform Tx-ED-Omni and Tx-ED-Dir at all loading levels and users percentiles with larger benefits to tail users.
 |
|  |  |

### Agreement #41:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

For Indoor scenario A:

* Huawei shows Receiver-only LBT (RxA-3) tail UPT and mean UPT gain compared to receiver-assisted LBT (RxA-2) in low, medium, and high traffic loads with InH Open Office channel model [40] and InH mixed channel model [40].
* Ericsson’s results in Coexistence scenario with Operator A doing No-LBT and Operator B doing TxED-Omni LBT at -47 dBm EDT show that the operator B performance does not degrade (i.e. no losses observed) as compared to the case when Operator B coexists with another operator using LBT.
* Ericsson’s results for Dynamic LBT shows that the performance of the network can be improved when the decision to perform LBT is done dynamically per node, as compared to semi-statically operating all nodes with LBT.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.2**

For Indoor scenario A, following observations were made:* Results from [72] shows receiver-only LBT (RxA-3) tail UPT and mean UPT gain compared to receiver-assisted LBT (RxA-2) in low, medium, and high traffic loads with InH Open Office channel model and InH mixed channel model.
* Results from source [65] in coexistence scenario with Operator A performing No-LBT and Operator B performing TxED-Omni LBT at -47 dBm EDT show that the operator B performance does not degrade (i.e. no losses observed) as compared to the case when Operator B coexists with another operator using LBT.
* Results from source [65] for Dyn-RxA shows that the performance of the network can be improved when the decision to perform LBT is done dynamically per node, as compared to semi-statically operating all nodes with LBT.
 |
|  **Company** | **Comments** |
| Ericsson 2 | Dynamic LBT can be replaced by Dyn-RxA for consistency.  |
| Moderator | Updated as suggested by Ericsson. |

### Agreement #42:

Capture the following in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

* One Company [Ericsson] submitted results for Indoor Scenario B, which is a smaller indoor scenario with 2 operators and 1 gNB each. Their observations for this case are in line with their observations for Indoor Scenario A.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.3**
* One source submitted results for Indoor Scenario B in [65], which is a smaller indoor scenario with 2 operators and 1 gNB each. Their observations for this case are in line with their observations for Indoor Scenario A.
 |
|  **Company** | **Comments** |
| Huawei2, HiSilicon2 | ”company” should be changed to ”source”. |
| Moderator | Updated as suggested by Huawei. |

### Agreement #43:

Capture the following in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

* Comparison of No-LBT with omnidirectional LBT (TxED-Omni) for Indoor Scenario C: Ericsson and HW show loss for TxED-Omni LBT, Charter shows roughly comparable performance
* Ericsson’s results show worse performance for TxED-Omni LBT relative to No-LBT for both threshold -47dBm and -68 dBm. The loss is higher for EDT -68dBm.
* Charter’s low load DL:UL 50:50 results show loss for TxED-Omni LBT over No-LBT. Their medium load DL:UL 5:2 results show gains in DL tail user and UL median user, loss in UL tail user and comparable performance for other cases. Their high load results for DL:UL ~2:1, show small tail gain and median loss for DL and comparable performance for UL.
* Huawei’s results show loss for TxED-Omni LBT over No-LBT at -47dBm EDT for gNB and -32dBm EDT for UE.
* Comparison of omnidirectional LBT (TxED-Omni) with directional LBT (TxED-Dir) for Indoor Scenario C:
* In Huawei and Ericsson’s results, for equal ED threshold, Directional sensing, (TxED-Dir) and Omni sensing (Tx-ED-Omni) show comparable results.
* ZTE show gains for directional LBT in median users as well as tail users at -68 dBm ED threshold for 100% DL traffic
* Comparison of Rx-Assistance LBT schemes with others for Indoor scenario C:
* Ericsson results show similar performance of Rx Assistance (RxA-1 -Omni) and TxED-Omni LBT but loss relative to no-LBT at both modelled ED thresholds. There is no benefit of using RxA-1 scheme over TxED-Dir LBT scheme for ED Threshold -47dBm.
* Another form of Rx-Assistance, referred as, Dyn-RxA is shown by Ericsson to provide similar performance as No-LBT for ED Threshold -47 dBm.
* Huawei’s results show consistent loss for receiver assistance scheme RxA-2 compared to No-LBT. RxA-2 is shown to outperform TxED-Omni and TxED-Dir for this scenario.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.4**
* For comparison of No-LBT with omnidirectional LBT (TxED-Omni) for Indoor Scenario C, source [65], and source [72] show loss for TxED-Omni LBT, source [71] shows roughly comparable performance.
* Results from [65] show worse performance for TxED-Omni LBT relative to No-LBT for both threshold -47 dBm and -68 dBm. The loss is higher for EDT -68 dBm.
* Results from [71] with low load and DL:UL ratio of 50:50 show loss for TxED-Omni LBT over No-LBT. Their medium load DL:UL ratio 5:2 results show gains in DL tail user and UL median user, loss in UL tail user and comparable performance for other cases. Their high load results for DL:UL ratio ~2:1, show small tail gain and median loss for DL and comparable performance for UL.
* Results from [72] show loss for TxED-Omni LBT over No-LBT at -47 dBm EDT for gNB and -32 dBm EDT for UE.
* For comparison of omnidirectional LBT (TxED-Omni) with directional LBT (TxED-Dir) for Indoor Scenario C, following observations were made:
* Results from source [72] and [65] with equal ED threshold, Directional sensing (TxED-Dir) and Omni sensing (Tx-ED-Omni) show comparable results.
* Results from source [64] show gains for directional LBT in median users as well as tail users at -68 dBm ED threshold for 100% DL traffic
* For comparison of Rx-Assistance LBT schemes with others for Indoor scenario C, the following observations were made:
* Results from [65] results show similar performance of Rx Assistance (RxA-1 -Omni) and TxED-Omni LBT but loss relative to no-LBT at both modelled ED thresholds. There is no benefit of using RxA-1 scheme over TxED-Dir LBT scheme for ED Threshold -47 dBm.
* Another form of Rx-Assistance, referred as, Dyn-RxA is shown by source [65] to provide similar performance as No-LBT for ED Threshold -47 dBm.
* Results from [72] show consistent loss for receiver assistance scheme RxA-2 compared to No-LBT. RxA-2 is shown to outperform TxED-Omni and TxED-Dir for this scenario.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #44:

Capture the following in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

For outdoor scenario B:

* Ericsson results show loss of TxED-Omni LBT schemes compared to No-LBT, for two ED thresholds (-47 and -68 dBm). TxED-Omni LBT with ED Threshold of -68 dBm dBm and -47 dBm has similar performance. HW shows loss for LBT schemes with respect to no-LBT for 1-site and 7 -site scenarios. Directional and omni LBT are comparable at -47dBm EDT for gNB and -32dBm EDT for UE.
* Huawei results show loss of TxED Omni LBT scheme compared to No-LBT for ED Threshold -47 dBm. TxED Omni and TxED-Dir are shown to have comparable performance. Receiver assisted LBT (RxA-2) is seen to improve tail performance and to a small extent median user performance at high loading levels compared to TxED-Omni, and in all other cases seen to have comparable performance. RxA-2 simulated underperforms No-LBT in all cases. These trends hold for 7-site as well as 1-site simulations.

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.5**

For outdoor scenario B, following observations were made:* Results from source [65] show loss of TxED-Omni LBT schemes compared to No-LBT, for two ED thresholds -47 and -68 dBm. TxED-Omni LBT with ED Threshold of -68 dBm and -47 dBm has similar performance.
* Results from source [72] shows loss for LBT schemes with respect to no-LBT for 1-site and 7 -site scenarios. Directional and omni LBT are comparable at -47dBm EDT for gNB and -32dBm EDT for UE.
* Results from source [72] show loss of TxED Omni LBT scheme compared to No-LBT for EDT -47 dBm. TxED Omni and TxED-Dir are shown to have comparable performance. Receiver assisted LBT (RxA-2) is seen to improve tail performance and to a small extent median user performance at high loading levels compared to TxED-Omni, and in all other cases seen to have comparable performance. RxA-2 simulated underperforms No-LBT in all cases. These trends hold for 7-site as well as 1-site simulations.
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #48:

Capture the following observations in the TR. Editorial modifications and changes to references can be made when capturing the observations in the TR.

The following flavors of channel access schemes have been modeled.

* ‘No-LBT’: No LBT Dynamic TDD: NR operation with no restrictions on channel access mechanism.
* ‘TxED-omni’: Tx side ED Based LBT with Omnidirectional Sensing (‘Tx Omni LBT): Baseline LBT with sensing at the transmitter is expected to closely follow the ETSI En 302 567 based medium access procedure
* ‘TxED-Dir’, Tx Side ED Based LBT with Directional Sensing (‘Tx Directional LBT’)
* Rx Assisted LBT Flavors: Multiple flavors of Rx Assistance have been modelled
	+ RxA-1: [20, Ericsson], Receiver assisted LBT: the LBT procedure is evaluated at the receiver instead of transmitter. The LBT result is assumed to be available instantly at the transmitter without accounting any overhead for exchanging this information between the transmitter and the receiver
	+ RxA-2: [4, Huawei/HiSilicon] [40, Huawei/HiSilicon]: Receiver performs directional LBT but transmitter performs Omni LBT. Further details for RxA-2 are as follows. When UE is the receiver, UE receives a RTS from the gNB. Then, UE sends a “message B” to the gNB with CCA measurements results (dBm value of the measured interference) upon a successful LBT procedure. The latency from the reception of RTS to the transmission of “message B” is calculated equal to 4 slots for 120 kHz SCS and 22 slots for 960 kHz SCS. This includes the required time at the UE side for CCA. Then, gNB transmits PDSCH to the UE. The PDSCH processing time is calculated as 3 slots for 120 kHz and 13 slots for 960 kHz. A CAT4 LBT is performed at the gNB side before RTS transmission. When gNB is the receiver, first gNB performs energy measurement at the directions of the UEs that have UL data. Then, gNB selects the UE with the lowest interference level. After, gNB sends PDCCH to schedule PUSCH transmission of that UE. Finally, PUSCH is transmitted after a successful CAT2 LBT. In our simulations, we have considered the preparation time from PDCCH reception to PUSCH transmission equal to 4 slots for 120 kHz SCS and 22 slots for 960 kHz SCS. A processing time for PUSCH at gNB is not modelled. The transmissions are restricted to Rank 1 for DL as well as UL throughout.
	+ RxA-3: [4, Huawei/HiSilicon] [40, Huawei/HiSilicon]: Only Receiver performs directional LBT procedure. The procedure is similar to RxA-2 except that gNB does not perform any LBT before RTS transmission.
	+ RxA-4: [6, Vivo]: RTS and CTS type mechanism is deployed after winning contention before transmission. The RTS/CTS type exchange is between serving gNB and the served UEs. The transmitter sends a request, and the receiver feedbacks a confirmation if the request could be successfully decoded. Unlike RTS/CTS mechanism in 802.11ad, both the request and confirmation do not silence any other node. The processing delay for the RTS/CTS is assumed to be zero. There is no LBT before CTS.
	+ RxA-5: [36, Qualcomm]: Rx Assistance takes the form of protecting ongoing transmissions by silencing based on sensing at the transmitters and protecting intended transmission by silencing based on sensing at the receiver. The receiver also assists by sending silencing signals. Omni and directional sensing is applied at all nodes. In the simulated procedure, the ECCA is performed at the gNB followed by an exchange of request/response transmissions.
* Other LBT Flavors:
	+ ‘Dyn-RxA’: Dynamic [20, Ericsson], Dynamic LBT: a node operates without LBT unless the receiver experiences a failure in reception due to a drop in SINR, which reflects a presence of interferer. Only then, the node switches to LBT. Besides, when the LBT is switched on, the RAL described in section 2.1.4 of R1-2007983 is used

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.1**

The following flavors of channel access schemes have been modeled.* No-LBT: No LBT with Dynamic TDD. NR operation with no restrictions on channel access mechanism.
* TxED-omni: Tx side ED Based LBT with omnidirectional sensing, also referred to as ‘Tx Omni LBT’. Baseline LBT with sensing at the transmitter is expected to closely follow the ETSI EN 302 567 [4] based medium access procedure.
* TxED-Dir: Tx side ED Based LBT with directional sensing, also refered to as ‘Tx Directional LBT’.
* Multiple flavors of Rx Assistance have been modelled. The following are list of Rx Assisted LBT flavors:
	+ RxA-1: Receiver assisted LBT from source [65]. The LBT procedure is evaluated at the receiver instead of transmitter. The LBT result is assumed to be available instantly at the transmitter without accounting any overhead for exchanging this information between the transmitter and the receiver.
	+ RxA-2: From source [72]. Receiver performs directional LBT but transmitter performs Omni LBT. Further details for RxA-2 are as follows. When UE is the receiver, UE receives an RTS from the gNB. Then, UE sends a "message B" to the gNB with CCA measurements results (dBm value of the measured interference) upon a successful LBT procedure. The latency from the reception of RTS to the transmission of "message B" is calculated equal to 4 slots for 120 kHz SCS and 22 slots for 960 kHz SCS. This includes the required time at the UE side for CCA. Then, gNB transmits PDSCH to the UE. The PDSCH processing time is calculated as 3 slots for 120 kHz and 13 slots for 960 kHz. A CAT4 LBT is performed at the gNB side before RTS transmission. When gNB is the receiver, first gNB performs energy measurement at the directions of the UEs that have UL data. Then, gNB selects the UE with the lowest interference level. After, gNB sends PDCCH to schedule PUSCH transmission of that UE. Finally, PUSCH is transmitted after a successful CAT2 LBT. In our simulations, we have considered the preparation time from PDCCH reception to PUSCH transmission equal to 4 slots for 120 kHz SCS and 22 slots for 960 kHz SCS. A processing time for PUSCH at gNB is not modelled. The transmissions are restricted to Rank 1 for DL as well as UL throughout.
	+ RxA-3: From source [72]. Only Receiver performs directional LBT procedure. The procedure is similar to RxA-2 except that gNB does not perform any LBT before RTS transmission.
	+ RxA-4: From source [37]. RTS and CTS type mechanism is deployed after winning contention before transmission. The RTS/CTS type exchange is between serving gNB and the served UEs. The transmitter sends a request, and the receiver feedbacks a confirmation if the request could be successfully decoded. Unlike RTS/CTS mechanism in IEEE 802.11ad, both the request and confirmation do not silence any other node. The processing delay for the RTS/CTS is assumed to be zero. There is no LBT before CTS.
	+ RxA-5: From source [56]. Rx Assistance takes the form of protecting ongoing transmissions by silencing based on sensing at the transmitters and protecting intended transmission by silencing based on sensing at the receiver. The receiver also assists by sending silencing signals. Omni and directional sensing are applied at all nodes. In the simulated procedure, the ECCA is performed at the gNB followed by an exchange of request/response transmissions.
* Other LBT flavors:
	+ Dyn-RxA: Dynamic LBT from source [65]: a node operates without LBT unless the receiver experiences a failure in reception due to a drop in SINR, which reflects a presence of interferer. Only then, the node switches to LBT. Besides, when the LBT is switched on RxA-1 is used.
 |
|  **Company** | **Comments** |
| Huawei2, HiSilicon2 | Unclear what this means “the RAL described in section 2.1.4”. Is section 2.1.4 in the TR? RAL is not a defined abbreviation. |
| Moderator | I am going to guess, it should have said, RA LBT or receiver assisted LBT. Will update. |
| Ericsson 2 | “the receive assisted LBTRAL described in section 2.1.4 of R1-2007983[45] is used. “ can be replaced by “RxA-1 is used” |
| Moderator | Updated as suggested by Ericsson. |

### Agreement #49:

Capture the tables in Section 3.3 of R1-2009626 in the TR with the following modifications:

* Change “DL:UL” to “DL:UL traffic ratio” in tables.
* Add “1:1” in Table 1 for vivo’s results in the “DL:UL traffic ratio” column
* Remove “No backoff” in Qualcomm’s results in Table 1

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture text above under Section 6.2.4**
 |
|  **Company** | **Comments** |
|  |  |

### Agreement #50:

Section 2 of R1-2009356 is endorsed for inclusion in the TR (formatting and other minor errors can be corrected when including in the TR).

|  |
| --- |
| ***Rapporteur suggestion for capturing agreement/conclusion (actual ordering will be done considering other TP for the same section):***1. **Capture agreed to Annex B with formtating and misc. typos and errors.**
 |
|  **Company** | **Comments** |
|  |  |

# Other Editorial aspect of TR

|  |  |
| --- | --- |
|  **Company** | **Comments** |
| Huawei | Comments on abbreviations: 37.213 uses “Energy Detection”ED                      Energy DetectEDT                   Energy Detect Threshold |
| Moderator | Updated to “Detection” |
| Huawei | Section 5.2.2 “Interference mitigation techniques when no-LBT is applied”: the title does not match the content, as LBT is also addressed in that section. |
| Moderator | Based on Huawei’s comments:Updated section title to “Interference mitigation techniques” and swapped the ordering of 5.2.2 and 5.2.1. |
| LG | * 3.3 Abbreviations
	+ “Channel” is missing

OCB         Occupied Channel Bandwidth |
| Moderator | Updated as suggested by LG. |

# Conclusions for TR

Below is the conclusion paragraph for the TR.

--------------------------

Study of required changes to NR using existing DL/UL NR waveform to support operation between 52.6 GHz and 71 GHz was conducted. The study included study of applicable numerology including subcarrier spacing, channel BW (including maximum BW), and their impact to FR2 physical layer design to support system functionality considering practical RF impairments, and identification potential critical problems to physical signal/channels, if any. Study of channel access mechanism, considering potential interference to/from other nodes, assuming beam based operation, in order to comply with the regulatory requirements applicable to unlicensed spectrum for frequencies between 52.6 GHz and 71 GHz was also conducted.

As an outcome of the study, it is recommended to support 120 kHz subcarrier spacing with normal CP length, and at least one more subcarrier spacing among 240 kHz, 480 kHz, and 960 kHz subcarrier spacing candidates. Subcarrier spacing outside 120 kHz to 960 kHz are not supported for any signals and channels. The applicability of the supported subcarrier spacing to particular signals and channels should be further discussed in the corresponding WI phase. It is additionally recommended to limit the maximum FFT size required to 4096 and to limit the maximum of RBs per carrier to 275 RBs. The candidate supported maximum carrier bandwidth(s) for a cell should be between 400 MHz and 2160 MHz. Further investigation of the details of required changes to NR may be needed.

As an outcome of the channel access study, it is recommended to support both channel access with LBT mechanism(s) and a channel access mechanism without LBT for gNB and UE that initiate a channel occupancy. Further investigation of the details of the channel access mechanism may be needed.

-----------------------------

|  |  |
| --- | --- |
|  **Company** | **Comments** |
| Moderator | I’ve only tried to summary the key components and left all other details out. If we start to insert caveats and additional observations and studies. I am fraid the whole conclusion section might not get agreed.Given that all the agreements are anyway captured, I ask companies to refrain from adding more conclusion, unless you believe it is absolutely critical. However, please do provide comments on removal of information that you don’t think would be essential.I would preferr to keep the conclusion short as possible to avoid any further debates. So removal of aspects are welcomed. |
| Ericsson 2 | We support the moderator's proposal for conclusions |
| LG Electronics | Support the Moderator’s proposal for TR conclusion. |
| Huawei/HiSilicon3 | We suggest the following change to align it with the actual text of the agreement:* + **It is recommended to support both channel access with LBT mechanism(s) and a channel access mechanism without LBT for gNB and UE to initiate a channel occupancy**
 |

# References:

Rapporteur: Companies are encouraged to check the correct Tdoc number for referencing the evaluation results. Below are the Reference that will be captured to the TR. Reference are from Summary #3 of the discussion. Reference should have [X+4], where X is the original numbering from the summary #3 of the discussion.

|  |
| --- |
| 2 ReferencesThe following documents contain provisions which, through reference in this text, constitute provisions of the present document.- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.- For a specific reference, subsequent revisions do not apply.- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.[1] 3GPP TR 38.913: "Study on Scenarios and Requirements for Next Generation Access Technologies"[2] 3GPP TR 38.807: "Study on requirements for NR beyond 52.6 GHz".[3] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications". [4] ETSI EN 302 567 v2.1.20: "Multiple-Gigabit/s radio equipment operating in the 60 GHz band; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".[5] R1-2007549 "Further discussion on B52 numerology" FUTUREWEI.[6] R1-2007558 "Discussion on physical layer impacts for NR beyond 52.6 GHz" Lenovo, Motorola Mobility.[7] R1-2007604 "PHY design in 52.6-71 GHz using NR waveform" Huawei, HiSilicon.[8] R1-2007642 "Physical layer design for NR 52.6-71GHz" Beijing Xiaomi Software Tech.[9] R1-2007652 "Discussion on required changes to NR using existing DL/UL NR waveform" vivo.[10] R1-2007785 "Consideration on required changes to NR using existing NR waveform" Fujitsu.[11] R1-2007790 "Consideration on supporting above 52.6GHz in NR" InterDigital, Inc.[12] R1-2007847 "System Analysis of NR opration in 52.6 to 71 GHz" CATT.[13] R1-2007883 "Required changes to NR using existing DL/UL NR waveform" TCL Communication Ltd.[14] R1-2007926 "Required changes to NR using existing DL/UL NR waveform" Nokia, Nokia Shanghai Bell.[15] R1-2007929 "On phase noise compensation for NR from 52.6GHz to 71GHz" Mitsubishi Electric RCE.[16] R1-2009379 "Discussion on Required Changes to NR in 52.6 – 71 GHz" Intel Corporation.[17] R1-2007965 "On the required changes to NR for above 52.6GHz" ZTE, Sanechips.[18] R1-2007982 "On NR operations in 52.6 to 71 GHz" Ericsson.[19] R1-2009653 "Consideration on required physical layer changes to support NR above 52.6 GH" LG Electronics.[20] R1-2008076 "Discussion on required changes to NR using existing DL/UL NR waveform in 52.6GHz ~ 71GHz" CMCC.[21] R1-2008082 "Study on the numerology to support 52.6 GHz to 71GHz" NEC.[22] R1-2008872 "Design aspects for extending NR to up to 71 GHz" Samsung.[23] R1-2008250 "Discusson on required changes to NR using DL/UL NR waveform" OPPO.[24] R1-2008353 "Considerations on required changes to NR from 52.6 GHz to 71 GHz" Sony.[25] R1-2008457 "A Discussion on Physical Layer Design for NR above 52.6GHz" Apple.[26] R1-2008493 "Discussions on required changes on supporting NR from 52.6GHz to 71 GHz" CAICT.[27] R1-2008501 "On required changes to NR using existing DL/UL NR waveform for operation in 60GHz band" MediaTek Inc.[28] R1-2008516 "On NR operation between 52.6 GHz and 71 GHz" Convida Wireless.[29] R1-2009062 "Evaluation Methodology and Required Changes on NR from 52.6 to 71 GHz" NTT DOCOMO, INC.[30] R1-2008615 "NR using existing DL-UL NR waveform to support operation between 52p6 GHz and 71 GHz" Qualcomm Incorporated.[31] R1-2008726 "Discussion on physical layer aspects for NR beyond 52.6GHz" WILUS Inc.[32] R1-2008769 "Waveform considerations for NR above 52.6 GHz" Charter Communications.[33] R1-2007550 "On channel access modes in 60GHz" FUTUREWEI.[34] R1-2007559 "Discussion on channel access for NR beyond 52.6 GHz" Lenovo, Motorola Mobility.[35] R1-2008976 "Channel access mechanism for 60 GHz unlicensed operation" Huawei, HiSilicon.[36] R1-2007643 "Channel access mechanism for NR on 52.6-71 GHz" Beijing Xiaomi Software Tech.[37] R1-2007653 "Discussion on channel access mechanism" vivo.[38] R1-2007791 "On Channel access mechanisms" InterDigital, Inc.[39] R1-2007848 "Channel Access Mechanism in support of NR operation in 52.6 to 71 GHz" CATT.[40] R1-2007884 "Channel access mechanism" TCL Communication Ltd.[41] R1-2007918 "Channel access mechanisms for NR from 52.6-71GHz" AT&T.[42] R1-2009312 "Design of NR channel access mechanisms for 60 GHz unlicensed band" Nokia, Nokia Shanghai Bell.[43] R1-2009380 "Channel Access Procedure for NR in 52.6 - 71 GHz" Intel Corporation.[44] R1-2007966 "On the channel access mechanism for above 52.6GHz" ZTE, Sanechips.[45] R1-2007983 "Channel Access Mechanism" Ericsson.[46] R1-2008046 "Considerations on channel access mechanism to support NR above 52.6 GHz" LG Electronics.[47] R1-2008091 "Discussion on channel access mechanism for above 52.6GHz" Spreadtrum Communications.[48] R1-2008157 "Channel access mechanism for 60 GHz unlicensed spectrum" Samsung.[49] R1-2008251 "Discussion on channel access" OPPO.[50] R1-2008354 "Channel access mechanism for 60 GHz unlicensed spectrum" Sony.[51] R1-2008458 "Views on Channel Access Mechanisms for Unlicensed Access above 52.6 GHz" Apple.[52] R1-2008494 "Discussions on channel access mechanism on supporting NR from 52.6GHz to 71 GHz" CAICT.[53] R1-2008517 "On Channel Access Mechanism and Interference Handling for Supporting NR from 52.6 GHz to 71 GHz" Convida Wireless.[54] R1-2008548 "Channel Access Mechanism for NR in 60 GHz unlicensed spectrum" NTT DOCOMO, INC.[55] R1-2008563 "Discussion on channel access mechanism" ITRI.[56] R1-2009362 "Channel access mechanism for NR in 52p6 to 71GHz band" Qualcomm Incorporated.[57] R1-2008717 "Discussion on channel access mechanism for 52.6 to 71GHz unlicensed ban" Potevio[58] R1-2008770 "Further aspects of channel access mechanisms" Charter Communications.[59] R1-2007560 "Additional evaluations for NR beyond 52.6GHz" Lenovo, Motorola Mobility.[60] R1-2007654 "Evaluation on different numerologies for NR using existing DL/UL NR waveform" vivo.[61] R1-2007792 "Evaluation results for above 52.6 GHz" InterDigital, Inc.[62] R1-2007928 "Simulation Results for NR from 52.6 GHz to 71 GHz" Nokia, Nokia Shanghai Bell.[63] R1-2007943 "Considerations on performance evaluation for NR in 52.6-71GHz" Intel Corporation.[64] R1-2009450 "Simulation results for NR above 52.6GHz" ZTE, Sanechips.[65] R1-2007984 "Evaluation results for NR in 52.6 - 71 GHz" Ericsson.[66] R1-2008047 "Considerations on phase noise compensation to support NR above 52.6 GHz" LG Electronics.[67] R1-2008873 "Evaluation results for extending NR to up to 71 GHz" Samsung.[68] R1-2009615 "Discussion on other aspects" OPPO.[69] R1-2008459 "Evaluation results for Physical Layer Design for NR above 52.6GHz" Apple.[70] R1-2008549 "Potential Enhancements for NR on 52.6 to 71 GHz" NTT DOCOMO, INC.[71] R1-2009157 "Performance evaluations for NR above 52.6 GHz" Charter Communications.[72] R1-2009610 "Link level and System level evaluation for NR system operating in 52.6GHz to 71GHz" Huawei, HiSilicon. |