**3GPP TSG-RAN WG4 Meeting # 97-e-Bis R4-200XXXX**

**Electronic Meeting, 2 – 13 Nov., 2020**

**Agenda item:** 13.2.1

**Source:** Moderator (Qualcomm Incorporated)

**Title: Draft -** Email discussion summary for [97e Bis]140FS\_NR\_52\_GHz\_Part\_1

**Document for:** Information

# Introduction

*This discussion is focused on topics addressing the feasibility of numerology in 52.5 to 71 GHz operation. 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..*

*List of candidate target of email discussion for 1st round and 2nd round*

* 1st round: TBA
* 2nd round: TBA

# Topic #1: Channel BW and SCS

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** | **Min** | **Max** |
| [**R4-2014382**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014382.zip) | CATT | **Proposal 1: At least one of 60 KHz and 120 KHz should be supported if 50 MHz CBW is supported by 52.6-71 GHz.**  **Proposal 2: 240 KHz SCS/4096 FFT size and 480 KHz SCS/2048 FFT size can be considered for 52.6-71 GHz.**  **Proposal 3: 960 KHz is not supported by 52.6-71 GHz.**  **Proposal 4: Only 2 SCSs are mandatory for 52.6-71 GHz if more than 2 SCSs are defined in spec.**  **Proposal 5: 50 MHz – 800 MHz single carrier bandwidth is defined for 52.6-71 GHz bands.** | **60k or 120k/50M** | **800M** |
| [**R4-2014737**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014737.zip) | CMCC | **Proposal 1: It is proposed to consider up to 480KHz SCS for 52.6GHz~71GHz.**  **Proposal 2: Considering up to 480KHz SCS, the maximum supported channel bandwidth in 52.6GHz ~71 GHz should be less than or equal to 1.6GHz.**  **Proposal 3: Carrier aggregation is needed to achieve competitive high peak data rate with 802.11ad/ay in 52.6GHz ~71 GHz** | **?120k/400M?** | **480k/1600M**  **CA to 8640M** |
| [**R4-2014892**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014892.zip) | Apple Inc. | **Proposal 1:** **Since the minimum/maximum channel bandwidth depends heavily on the selected SCS, the latter should be tackled first.**  **Proposal 2:** **The candidate SCS values for the 60GHz frequency range should be discussed further based on the RAN4 and RAN1 conclusion for the phase noise models.**  **Proposal 3:** **Accounting for different use cases and scenarios, carrier aggregation should be supported to cover larger spectrum available in the 60GHz frequency range.** | **CBW: Decide SCS first**  **120k** | **CBW: Decide SCS first**  **480k** |
| [**R4-2014974**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014974.zip) | vivo | **Observation 1：Numerology 960kHz SCS has a better EVM performance than other SCS in 60GHz.**  **Observation 2: Whether it is a CP-OFDM waveform or a DFT-S-OFDM waveform, PN compensation can effectively increase EVM performance**  **Proposal 1: (960K, NCP) with maximum 2GHz carrier BW and (120K, NCP) with maximum 400MHz carrier BW are preferred for 52.6-71GHz.**  **Observation 3: 2GHz carrier BW will result in more relative BW ratio than FR2.**  **Proposal 2: For (960K, NCP) with 2GHz carrier BW, RF requirements need to be relaxed considering the larger relative BW ratio.**  **Proposal 3. Minimum channel bandwidth 400MHz with 120kHz SCS should be supported for B52.6G.** | **120k/400M** | **960k/2000M** |
| [**R4-2015206**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015206.zip) | Nokia, Nokia Shanghai Bell | **Proposal 1: Define channelization according to 2.16 GHz CBW, which is preferred from coexistence point of view.**  **Proposal 2: Support sub-channelization for 2.16 GHz channels to facilitate smooth coexistence for narrowband operation.**  **Proposal 3: For operation without CA, support two CBWs: 400 MHz (120 kHz) and 2.16 GHz (960 kHz)**  **Proposal 4: Support CA within a 2.16 GHz channel, and between 2.16 GHz channels**  **Proposal 5: Consider n x 400 MHz, n= [2, 3, 4, 5] as the supported channel BW options for​ CA operation within a 2.16 GHz channel** | **120k/400M** | **960k/2160M** |
| [**R4-2015307**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015307.zip) | NEC | **l 1: Support 2.16 GHz as the maximum channel bandwidth and 400 MHz as the minimum channel bandwidth**  **Proposal 2: Support 240 kHz, 480 kHz, and 960 kHz subcarrier spacing for data transmission.** | **240k/400M** | **960k/2160M** |
| [**R4-2015563**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015563.zip) | Intel Corporation | **Proposal #1: Consider efficient ways to support aggregated wide bandwidth, such as up to 8 GHz or 8.64 GHz.**  **Proposal #2: Do not support 120 kHz subcarrier spacing for NR 52.6 GHz to 71 GHz.**  **Proposal #3: Define the minimum channel bandwidth as 800 MHz.**  **Proposal #4: Define maximum single carrier bandwidth as 2 GHz.** | **240k/800M** | **960k/2000M**  **Consider CA to 8640M** |
| [**R4-2015700**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015700.zip) | Huawei, HiSilicon | **Proposal 1: Maximum 400MHz carrier bandwidth with 120 kHz / 240 kHz SCS could be considered as the starting point for NR in frequency band between 52.6GHz and 71GHz.** |  | **120 or 240k/400M** |
| [**R4-2015727**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015727.zip) | Ericsson | **Proposal 1: RAN4 urgently send the LS response to RAN1 and recommend the usage of two up to date phase noise model sets.**  **Proposal 2: Inform RAN1 that 120 kHz and 480 kHz SCS are the RAN4 preferred numerologies for NR in 52.6-71 GHz.**  **Proposal 3: The carrier bandwidths for NR in 52.6-71 GHz should be ~400 MHz, ~800 MHz and ~1600 MHz.** | **120 kHz**  **400 MHz** | **480 kHz**  **1600 MHz** |
| [**R4-2015886**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015886.zip) | Sony | **Proposal 1: NR system should support 2.16 GHz bandwidth in the frequency range from 52 GHz to 71 GHz.**  **Proposal 2: Considering the RF complexity and signalling overhead of the NR system, it is preferred to support 2.16 GHz with a single CC**  **Proposal 3: Support the maximum SCS to at least 960 kHz for the NR system in the frequency range from 52 GHz to 71 GHz.** |  | **960k/2160M** |
| [**R4-2016110**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016110.zip) | ZTE Corporation | **Proposal 1: adopt the supported SCS as 120/240/480kHz for 52.6-71GHz;**  **Proposal 2: adopt the supported BW as 50/100/200/400MHz/800MHz for 52.6-71GHz;** | **120k/50M** | **480k/800M** |
| [**R4-2016299**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016299.zip) | Qualcomm Incorporated | Proposal 1: For physical control, data, and random access channels and for SSB in the high frequency regime from 52.6GHz to 71GHz, SCSs of 120kHz and 960kHz should be considered.  Proposal 2: 50 MHz channel bandwidth should be included. | 120k/50M | 960k/2160M |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1

*Sub-topic description: Minimum SCS*

*Open issues and candidate options before e-meeting:*

**Issue 1-1: Minimum SCS**

* Proposals
  + Option 1: Continue to discussion during the meeting
  + Option 2: Follow RAN1 decision and close discussion in RAN4
* Recommended WF
  + Option2

### Sub-topic 1-2

*Sub-topic description Maximum SCS*

*Open issues and candidate options before e-meeting:*

**Issue 1-2: Maximum SCS**

* Proposals
  + Option 1: continue to discuss the feasibility of either 480 or 960 kHz during the meeting
* Recommended WF
  + Option 1

### Sub-topic 1-3

*Sub-topic description Minimum CBW*

*Open issues and candidate options before e-meeting:*

**Issue 1-3: Minimum CBW**

* Proposals
  + Option 1: 50 MHz
  + Option 2: 400 MHz
  + Option 3: 800 MHz
* Recommended WF
  + Continue to discuss during the meeting

### Sub-topic 1-4

*Sub-topic description Maximum CBW*

*Open issues and candidate options before e-meeting:*

**Issue 1-4: Maximum CBW**

* Proposals
  + Option 1: 2160 MHz
  + Option 2: 2000 MHz
  + Option 3: 800 MHz
  + Option 4: 400 MHz
* Recommended WF
  + Continue to discuss these options during the meeting

### Sub-topic 1-5

*Sub-topic description Carrier aggregation*

*Open issues and candidate options before e-meeting:*

**Issue 1-5: Carrier aggregation**

* Proposals
  + Option 1: Continue to discuss CA during the meeting and during the follow-on WI
* Recommended WF
  + Option 1

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications, Inc. | **Issue 1-1: Minimum SCS,** We support Option 2: Follow RAN1 decision and close discussion in RAN4  **Issue 1-3: Minimum CBW,** We supportOption 3: 800 MHz |
| Charter communications, Inc (2) | **Issue 1-4: Max CBW,** We supportOption 1: 2160 MHz  Sorry for the typo |
| Intel | **Issue 1-1:** Option 2  **Issue 1-3:** Option 3 (800 MHz)  **Issue 1-4:** Option 2 (2000 MHz) |
| CMCC | **Issue 1-1:** We are OK to follow RAN1 decision on minimum SCS  **Issue 1-3:** The minimum CBW is also related to the supported minimum SCS. Should be discussed after minimum SCS is decided.  **Issue 1-4:** We think the maximum bandwidth should consider RAN1 agreement on maximum of 275RBs per carrier. The existing option does not reflect RAN1 agreement. For example, if 480KHz maximum SCS is supported, the maximum channel bandwidth is 1600GHz, if 960KHz maximum SCS is supported, the maximum channel bandwidth is 3.2GHz. |
| Ericsson: | Sub topic 1-1: We prefer minimum SCS to 120 kHz.  Sub topic 1-2: Considering UE UL timing aspects (strict UE timing requirements at high SCS, for initial access error, TA setting accuracy and TA step size) 480 kHz SCS is a reasonable maximum value for this frequency range.  Sub topic 1-3: We prefer minimum CBW 400 MHz. Based on analysis in R4-2015727 not captured in the summary above.  Sub-topic 1-4: Consider channel bandwidths up to 1.6 GHz for NR operation in 52.6 to 71 GHz. The reasons are stated in R1-2007982 section 2.2.  Sub-topic 1-5: Option 1, We should study the possibility to use CA to find reasonable granularity to make use of relevant spectrum. |
| Qualcomm Inc | **Issue 1-1: Minimum SCS**   * Option 2: Follow RAN1 decision and close discussion in RAN4   **Issue 1-2: Maximum SCS**   * 960 kHz SCS to enable ~ 2 GHz CBW to be competitive with 802.11   **Issue 1-3: Minimum CBW**   * Option 1: 50 MHz for deployments outdoors with ISD of approx. 80m   **Issue 1-4: Maximum CBW**   * Option 1: 2160 MHz or Option 2: 2000 MHz to be competitive with 802.11   **Issue 1-5: Carrier aggregation**  We welcome discussion during the meeting however we think CA should be part of the WID discussion where the channelization will be discussed in more detail. |
| NEC | **Issue 1-1:** Option 2  **Issue 1-3:** Option 2  **Issue 1-4:** Option 1 or 2 |
| Vivo | **Issue 1-1: Minimum SCS**  Option 2 is OK for us.  **Issue 1-2: Maximum SCS**  960kHz should be supported to achieve maximum 2GHz CHBW.  **Issue 1-3: Minimum CBW**  o Option 2: 400 MHz  **Issue 1-4: Maximum CBW**  o Option 2: 2000 MHz |
| CATT | **Issue 1-1: Minimum SCS**  Ok to follow RAN1 decision.  **Issue 1-2: Maximum SCS**  480 KHz  **Issue 1-3: Minimum CBW**   * + Option 1: 50 MHz   **Issue 1-4: Maximum CBW**   * + Option 3: 800 MHz   **Issue 1-5: Carrier aggregation**  We think some high level discussion can happen like if CA can be allowed to support the large BW spectrum. |
| Huawei | Issue 1-1: Minimum SCS: Agree recommended WF, option 2  Issue 1-2: Maximum SCS: It can also firstly follow RAN1 conclusion  Issue 1-3: Minimum CBW: We support option 1: 50 MHz  Issue 1-4: Maximum CBW: It is pending the conclusion of maximum SCS.  Issue 1-5: CA: to reflect that CA is expected to be supported to address availability of wide spectrum chunks in this range. |
| ZTE | **Issue 1-1: Minimum SCS**  Fine with further discussion in RAN4, however we prefer to adopt 120KHz as minimum SCS  **Issue 1-2: Maximum SCS**  Support the maximum SCS as 480KHz. In addition, whether it could support 64QAM is still questionable as phase noise contribution is close to EVM requirements;  **Issue 1-3: Minimum CBW**  Support 50MHz as minimum CBW to give better granularity for spectrum assignment.  **Issue 1-4: Maximum CBW**  Support 800MHz as maximum CBW based on the increasing SCS up to 480KHz. |
| Sony | **Issue 1-1: Minimum SCS**  **Option 2: Follow RAN1 decision and close discussion in RAN4.**  **Issue 1-2: Maximum SCS**  **Maximum SCS = 960kHz.** 960 kHz is needed to support the bandwidth of 2160 MHz with 4096 FFT. Besides, according to our simulation results in [R4-2015886](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015886.zip), 960 kHz can also provide better EVM performance under a critical phase noise situation at these higher frequency bands, especially with a high-order MCS.  **Issue 1-4: Maximum CBW**  **Option 1: 2160 MHz.** Support 2160 MHz can provide better co-existence performance and also offer compatible channel bandwidth with other networks in unlicensed spectrum. |

### CRs/TPs comments collection

*Major close-to-finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Phase noise and Phase tracking reference signal

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2014893**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014893.zip) | Apple Inc. | **Proposal 1: RAN4 agrees on sending a LS to RAN1 to inform that Model 2 is a more precise phase noise model for the frequency range from 52.6 to 71 GHz,**  **Proposal 2: Feasibility study for 64-QAM EVM for 60 GHz frequency range is required.** |
| [**R4-2014976**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014976.zip) | Ericsson | **Proposal 1: Consider the following phase noise model for evaluating the designs of NR operation in the 52.6 – 71 GHz frequency range:**  **Proposal 2: Consider 0 dB design margin for BS and 5 dB design margin for UE used in the proposed new phase noise model to cater for variation in manufacturing process, frequency, temperature and UE constraints on power consumption.**  **Proposal 3: Send a RAN4 LS response to RAN1 informing about the two new proposed models and recommend usage of proposed models for numerology studies in RAN1.**  **New model 1: The model presented in this paper with 0 dB design margin for BS and 5 dB design margin for UE.**  **New model 2: The BS model based on TR 38.803 Ex2 for BS and model presented in R4-2011494 for UE.**  **Proposal 4: It is proposed to document the phase noise model presented in this paper in the technical report.** |
| [**R4-2015443**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015443.zip) | Nokia, Nokia Shanghai Bell | **Observation 1: Most recent reference for phase noise performance studies is 7-24 GHz frequency range, as documented in TR 38.820.**  **Observation 2: Commercial components included here have high current consumption and unit cost, and would be likely to be considered only for infrastructure side applications needing highest quality.**  **Observation 3: TR 38.803 example 2 UE model and some company proposals are rather aligned, especially considering that in [5] and [6] the published data is gathered limiting to cases with low current consumptions, therefore being not only applicable for infrastructure.**  **Observation 4: For 960 kHz SCS, 64QAM provides robust performance already with a simple CPE compensation while 480 kHz SCS suffers from a major performance degradation due to phase noise.**  **Observation 5: Both 960 kHz SCS and 480 kHz SCS provide robust performance with ICI compensation. However, for a wideband scenario (which is the main use case for a high SCS), 960 kHz SCS provides up-to 0.8 dB gain compared to 480 kHz SCS.**  **Observation 6: OFDM with CPE compensation**   * **Only QPSK and 16-QAM can be supported with SCS<960 kHz.** * **64-QAM requires SCS=960 kHz with reasonable performance.** * **Delay spread 5 or 10ns does not have big impact on the result, except that 1920kHz SCS suffers some performance loss for 10ns, which may be due to the too small CP size.**   **Observation 7: ICI cancellation enables 120kHz SCS for at least up to 64-QAM.**  **Observation 8: ICI compensation provides significant improvement to performance, especially for 480 kHz and lower SCS. Two approaches are discussed:**   * **Enhanced PT-RS design (e.g. localized/block PT-RS)** * **Implementation-based method (e.g. data-aided direct filtering.)**   **Observation 9: DFT-s-OFDM is more robust under phase noise than CP-OFDM, and can enable use of smaller SCS with significantly smaller PTRS overhead. Even 120kHz can be supported for 64-QAM.**  **Observation 10: New PTRS configurations for DFT-s-OFDM can provide significant performance improvements for higher-order modulations with smaller SCSs.**  **Observation 11. Normal CP seems to be enough for the considered channels.**  **Observation 12. RF impairments specified for FR2 are found to be applicable also to NR operation above 52.6 GHz.**  **Proposal 1: The target shall be to capture phase noise studies with similar level of detail as was found appropriate for 7-24 GHz frequency range in TR 38.820.**  **Proposal 2: Inform RAN1 that PHY-layer studies can go on using phase noise model from section 6.1.11 of TR 38.803, scaled to the applicable operating frequency.**  **Proposal 3: For detailed RAN4 requirement work, it should be further considered whether the loop bandwidths in TR 38.803 example 2 models need to be extended and the models adapted accordingly.**  **Proposal 4: Detailed LO-distribution architecture is an implementation specific aspect. RAN4 shall only model the phase noise performance of a complete BS or UE, and does not need to model the intricacies of numerous different LO-distribution options.**  **Proposal 5: Support 960kHz for CP-OFDM to enable use of high-order modulations with low complexity CPE compensation.**  **Proposal 6: Inform RAN1 on usefulness of ICI compensation for NR beyond 52.6GHz, and recommend to study and compare different ICI compensation schemes with respect to performance as well as implementation complexity.**  **Proposal 7: Support 960kHz SCS for DFT-s-OFDM to robustly enable all MCSs.**  **Proposal 8: Recommend RAN1 to consider defining new PTRS configurations for DFT-s-OFDM.**  **Proposal 9: Send on LS to RAN1 to reply the their questions and to inform RAN1 on new observations and recommendations from RAN4. Draft LS is provided in Appendix 2.**  **LS proposal is below, please see tdoc for the full proposal:**  **RAN4 would like to thank RAN1 for the LS. RAN4 has discussed the topics and concluded the following:**   * **RAN4 agrees that phase noise (PN) modelling is necessary in the evaluations. The phase noise models in TR 38.803 section 6.1.11 are applicable as long as they are properly scaled to applicable operating frequency. From RAN4 perspective it is sufficient to model the observed total phase noise level in the signal without taking into account the specifics of all applicable RF architectures.** * **The same frequency offset and IQ-imbalance levels specified for FR2 are applicable above 52.6 GHz.** * **Power amplifier modelling using a practical model will result in more accurate outcome than modelling PA impairments using a fixed additive EVM. RAN4 has no common agreed PA model and uses the trend of independent simulations in its evaluations.**   **Additionally, RAN4 has progressed in the study and would respectfully like to share the following observations**   * **Support of 960kHz for CP-OFDM is required to enable use of high-order modulations with low complexity CPE compensation.** * **Support of 960kHz SCS for DFT-s-OFDM is required to robustly enable all MCSs.** * **For 480 kHz and lower SCS, ICI compensation is found useful for NR beyond 52.6GHz. Therefore, it is recommended to study and compare different ICI compensation schemes with respect to performance as well as implementation complexity** * **New PTRS configurations are recommended to be considered.** |
| [**R4-2015564**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015564.zip) | Intel Corporation | **Proposal #1: Send LS to RAN1 to include newly proposed PN models for further RAN1 discussion along with the existing PN models in the TR 38.803.**  **Proposal #2: Reuse the same RF impairment assumptions in FR2 for 52.6 – 71 GHz.** |
| [**R4-2015728**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015728.zip) | Ericsson | Observation 1: Effective mitigation of ICI caused by phase noise for OFDM can be performed using the existing Rel-15 NR distributed PT-RS structure.  Observation 2: A clustered PT-RS structure does not offer any performance advantage over the existing Rel-15 NR distributed PT-RS structure.  Proposal 1: Retain the same Rel-15 distributed PT-RS structure for OFDM for NR operation in 52.6 to 71 GHz. |
| [**R4-2016298**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016298.zip) | Qualcomm Incorporated | Proposal 1: As PTRS enhancement for assisting ICI compensation, increasing the frequency domain PTRS density for small RB allocation can be considered. New PTRS patterns other than the Rel-15 design, such as the block PTRS pattern is not necessary. |
| [**R4-2016533**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016533.zip) | Huawei, HiSilicon | **Proposal 1: For 70GHz, take multiple zero/pole PN model, the parameters are assumed as in Table3.**  **Proposal 2: Send reply LS to RAN1 to inform them on PN model(s) for 52.6-71GHz, and ask RAN1 to include the PN model(s) in to TR 38.808.**  **Proposal 3：Include in reply LS to RAN1 that RAN4 sees enhancements to PT-RS may be useful for >52.6 GHz frequencies and respectfully asks RAN1 to take this into account in their work.** |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1

*Sub-topic description:PN model, PTRS, and potential LS*

*Open issues and candidate options before e-meeting:*

**Issue 2-1: PN models to include in potential reply LS out to RAN1. Delegates may choose more than one,**

* Proposals : Phase noise models to include in potential LS to RAN1 and in TR
  + Option 1: Include Ericsson R4-2014976 BS model with 0 dB margin
  + Option 2: Include Ericsson R4-2014976 UE model with 5 dB margin
  + Option 3: Include reference to TR 38.803 example 2 BS model as it is
  + Option 4: Include reference to TR 38.803 example 2 UE model as it is
  + Option 5: Include TR 38.803 example 2 UE and BS models scaled to operating frequency
  + Option 6: Include Huawei R4-2016533 UE PN model
  + Option 7: Exclude any reference to PN models
* Recommended WF
  + Companies discuss the options during round 1 of the meeting

**Issue 2-2: Phase tracking reference signal information to include in potential reply LS out to RAN1.**

* Proposals :
  + Option 1: Exclude PTRS info
  + Option 2: Recommend RAN1 to consider defining new PTRS configurations for DFT-s-OFDM.
  + Option 3: Inform RAN1 on usefulness of ICI compensation for NR beyond 52.6GHz, and recommend to study and compare different ICI compensation schemes with respect to performance as well as implementation complexity.
* Recommended WF
  + Companies discuss the options during round 1 of the meeting

**Issue 2-3: 64QAM Feasibility**

* Proposals
  + Option 1: Continue to discuss during the meeting with the expectation that this will be an area for discussion and analysis during the WI
* Recommended WF
  + Option 1

**Issue 2-4: Nokia/Nokia ShB Proposals**

* Proposals
  + Option 1: Discuss proposals 1,3,4,6 in [**R4-2015443**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015443.zip)
  + Proposal 1: The target shall be to capture phase noise studies with similar level of detail as was found appropriate for 7-24 GHz frequency range in TR 38.820.
  + Proposal 3: For detailed RAN4 requirement work, it should be further considered whether the loop bandwidths in TR 38.803 example 2 models need to be extended and the models adapted accordingly.
  + Proposal 4: Detailed LO-distribution architecture is an implementation specific aspect. RAN4 shall only model the phase noise performance of a complete BS or UE, and does not need to model the intricacies of numerous different LO-distribution options.
* Recommended WF
  + Discuss during the round 1 of the meeting

**Issue 2-5: RF impairments**

* Proposals
  + Option 1: Reuse the same RF impairment assumptions in FR2 for 52.6 – 71 GHz.
  + Option 2: Discuss RF impairment assumptions during this meeting and continuing into the follow-on WI.
* Recommended WF
  + Discuss during the round 1 of the meeting

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications Inc. | **Issue 2-1: PN models to include in potential reply LS out to RAN1. Delegates may choose more than one,** We support Intel’s proposal “to include newly proposed PN models for further RAN1 discussion along with the existing PN models in the TR 38.803”.  **Issue 2-2: Phase tracking reference signal information to include in potential reply LS out to RAN1.** We support Option 3: Inform RAN1 on usefulness of ICI compensation for NR beyond 52.6GHz, and recommend to study and compare different ICI compensation schemes with respect to performance as well as implementation complexity.  **Issue 2-5: RF impairments,** We support Option 1: Reuse the same RF impairment assumptions in FR2 for 52.6 – 71 GHz |
| Intel | **Issue 2-1:** Options listed are not orthogonal and could be multiple choices. Our view is sending new PN models to RAN1 for further evaluations in addition to the existing PN models in the TR. Based on our analysis, RAN4 metric like EVM does not fully reflect PN characteristics and requires link level performance evaluation.  **Issue 2-2:** Option 1. RAN4 already concluded PTRS is RAN1 responsibility and RAN1 already discusses the issue. No need further follow up or sending an LS from RAN4.  **Issue 2-3**: This issue will be discussed during WI phase anyway.  **Issue 2-4**: It might be useful to study and evaluate technology advanced in PLL. However, PLL along with LO distribution architecture is often considered as implementation and/or optimization choice. RAN4 should open door for several implementation choices.  **Issue 2-5**: Option 1. We believe the same RF impairment assumptions in FR2 can be reused for 52.6 – 71 GHz. |
| Ericsson: | Sub topic 2-1: In the LS to RAN1 we need to focus on new technical background more suitable for this specific frequency range. Therefore, we can not select on option only. We should collect new information and include models from option 1, option 2 and option 6. It is essential that RAN1 s using the correct technical assumptions for phase noise to draw correct conclusion on SCS and related parameters.  Sub topic 2-2: Based on our analysis we prefer option 1, we do not need to send any information regarding PT RS to RAN1.  Sub topic 2-3: Based on a relevant phase noise model we can continue to discuss link quality for different modulations schemes.  Sub topic 2-4: The intension with the topic summary is to summarize views from all contribution not comment specific papers. Comments to paper R4-2015443;  Proposal 1: We need to capture information relevant for this specific frequency range.  Proposal 2: We should focus on new information more suitable for this specific frequency range. Proposal 3: The non-physical corner of the curves in TR 38.803 is not a good reference for future work.  Proposal 4: This proposal is difficult to understand. There are two extremes; centralized (FR1 like LO) and de-centralized (more towards FR2). For this specific range we need to consider a more de centralized approach since AAS is the foundation for reasonable implementations.  Proposal 5: Lets discuss that in topic 1 above. We also need to consider the UL UE timing aspects for 960 kHz SCS.  Proposal 6: RAN1 is aware on the need of ICI compensation, we see no need to tell RAN1 what they need to study.  Proposal 7: Also consider UE UL timing aspect before deciding on 960 kHz, as pointed out in R4-2016036.  Proposal 8: No, we do not need a new PT-RS configuration. Background can be found in R4-2015728.  Proposal 9: We need a new version, reflecting the information in our draft LS included in R4-2014976.  Sub topic 2-5: Maybe we need a WF to describe different options and what is required for the SI |
| Qualcomm Incorporated | **Issue 2-1: PN models to include in potential reply LS out to RAN1. Delegates may choose more than one,**   * Option 7: Exclude any reference to PN models. RAN1 is working with TR 38.803 example 2 model which has been developed in 3GPP and is representative of feasible phase noise.   **Issue 2-2: Phase tracking reference signal information to include in potential reply LS out to RAN1.**   * Option 1: Exclude PTRS info. RAN1 is already working with this PTRS method. Our tdoc shows that rel15 PTRS is superior to block PTRS and provides good performance.   **Issue 2-3: 64QAM Feasibility**   * Option 1: Continue to discuss during the meeting with the expectation that this will be an area for discussion and analysis during the WI. Our tdoc shows good 64 QAM performance in TR 38.803 example 2 PN mask.   **Issue 2-4: Nokia/Nokia ShB Proposals**   * Proposal 1: PN information added as informative into TR 38.820 would be acceptable, allowing for different in actual implementation. * Proposal 3: Further considered whether the loop bandwidths in TR 38.803 example 2 models need to be extended and the models adapted accordingly in this meeting. At this time we have not analyzed. * Proposal 4: Detailed LO-distribution architecture should be an implantation choice and requirements should be based on various.   **Issue 2-5: RF impairments**   * Option 2. Impairments in this band need to be evaluated during the WI phase. Detailed study is needed to get this right for this new range. |
| vivo | **Issue 2-1: PN models to include in potential reply LS out to RAN1. Delegates may choose more than one,**  Both Option 5 and Option 7 are acceptable to us.  **Issue 2-2: Phase tracking reference signal information to include in potential reply LS out to RAN1.**  o Option 1: Exclude PTRS info.  **Issue 2-5: RF impairments**  o Option 1: Reuse the same RF impairment assumptions in FR2 for 52.6 – 71 GHz. |
| Huawei | **Issue 2-1:** RAN1 currently use the PN model in TR38.803 is because, there is no input from RAN4, and even they already send LS to RAN4 asking for information update. For 52.6-71GHz, PN is increasing much compared with FR1 and FR2, it has big impact on the LLS accuracy in RAN1. For model 2 of UE in current TR38.803, the curve is spliced by 2 separate line which generates an inflection point which will have big impact on simulation mathematically. However, it does not comply with the real situation of PLL implementation.  To get a more accurate and real embodied LLS, we should send LS to RAN1 inform them the PN update. From UE side, we don’t only recommend our own proposal, we think both option 2 and option 6 should be included in the LS for their info as new models for 52.6-71GHz. We don't need to anxious for RAN1 whether they have time to simulate more, we are focus on the PN model. For BS side, we actually think model 2 in TR 38.803 also have the problem on inflection point. Actually BS implementation could be better than UE side, BS PN model can also use option 6 assuming some implementation margin, meanwhile option 1 can also be included for BS in the LS for RAN1 consideration.  **Issue 2-2:** Option 2. According to the current PN model shown in RAN4, the residual EVM is still high, without further compensation, high order modulation is impossible. For ICI compensation with legacy PTRS pattern, it will add the implementation complexity and performance is worse than block PTRS according to our analysis.  **Issue 2-3**: This issue will be discussed during WI phase. Based on the current PN model shown in RAN4, 64QAM performance is not easy to reach.  **Issue 2-4:**  Proposal 1: The target shall be to capture phase noise studies with similar level of detail as was found appropriate for 7-24 GHz frequency range in TR 38.820.  *7-24GHz is not the same story of 52.6-71GHz. From UE perspective, the RF component and IC industry is totally different on these 2 frequency range. So 52-71GHz specific aspects can be captured in TR.*  Proposal 3: For detailed RAN4 requirement work, it should be further considered whether the loop bandwidths in TR 38.803 example 2 models need to be extended and the models adapted accordingly.  *We have already provided with the updated PN model, this can be considered as one of the option for 52.6-71GHz.*  **Issue 2-5**: Option 2.  PT-RS tdoc in R4-2015728 was included in [141] – probably it shall be shifter to [140] |
| ZTE | **Issue 2-1: PN model, PTRS, and potential LS**  Fine to further discuss PN model and in the LS, it;s not needed to mention PT-RS enhancement, it’s purely up to RAN1 design instead of RAN4.  **Issue 2-2: 64QAM Feasibility**  Intend to agree to further study 64QAM feasibility, form [R4-2014893](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014893.zip), it shows that PLL contributor is close to 64QAM EVM 8%.  **Issue 2-5: RF impairments**  Prefer option 2 |
| Sony | **Issue 2-1: PN model, PTRS, and potential LS**  We support to inform RAN1 the updated PN models which have been discussed in RAN4. |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

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| **CR/TP number** | **Comments collection** |
| R4-2015200 | Ericsson: The section on phase noise is not complete. There is no information on reference signal source quality and noise floor. Data comes from datasheet for PLL circuits, where the focus is on PLL noise characteristics. For a BS we need to consider a complete frequency generator and corresponding implementation margins. Also, no model is provided. In the figure, our model is visualized incorrectly, its 10 dB wrong. For this specific frequency range, we have more recent and more relevant information to be included from multiple companies. |
| Huawei: for PN model of our side, valid from 1000Hz.  This TP was listed in [141], but it also include PN text proposal. |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #3: Timing

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2016000**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip) | Nokia, Nokia Shanghai Bell | **Proposal 1: Maintain timing requirements related to the TDD guard periods.**  **Proposal 2: Improvement of TAE requirements shall be considered**  **Proposal 3: Wait for RAN1 decision on sub-carrier spacings for SSBs before advancing on the initial timing requirements.**  **Proposal 4: RAN4 to apply scaling of UE timing accuracy in Table 7.3.2.2-1 in TS 38.133 for wider SCS in >52.6 GHz, similarly to what is currently specified for existing SCS values.**  **Proposal 5: RAN4 to study the adaptation of the autonomous time adjustment parameters, Tq and Tp, for larger subcarrier spacings at >52.6 GHz carrier frequencies.**  Finally, it is proposed to capture the text proposal provided in Annex 1 to the TR 38.808. |
| [**R4-2016036**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016036.zip) | Ericsson | **Observation 1: For discussion around synchronization requirements, a holistic and complete view of the complete ARP timing budget must be considered.**  **Observation 2: Stricter TDD Cell Phase Synchronization requirement would mean that one cannot share already existing NR FR1/FR2 and LTE infrastructure and installations for synchronization.**  **Observation 3: The reduced TGUARD could be traded off with a higher UL/DL switch frequency (lower latency), compared to FR2 or more data (less overhead), again compared to FR2.**  **Observation 4: The shorter cell radii of 52.6 to 71 GHz will limit overhead, since guard period is lower for smaller cells.**  **Observation 5: Existing BS and UE transients and Cell Phase Synchronization requirements TGUARD = 3 µs, TBS = 3 µs and TUE = 5 µs, results in low overhead, 1.4 % and 1.8 %, for reasonable cell ranges of 140 meters up to 500 meters and the same switch point periodicity (in absolute time) as for SCS = 120 kHz. If the switch point periodicity increases, then overhead increases, but given the amount of spectrum available in 52.6 to 72 GHz range, this is less critical.**  **Observation 6: The Cell Phase Synchronization requirement, TSync in Equation 1, is only needed and defined for cells which are not isolated (overlapping).**  **Observation 7: Isolation could be achieved by physical separation, or the use of the fact that milli-meter wave frequency range is characterised by high propagation loss and directional transmission and reception, from the use of large antenna arrays.**  **Observation 8: It Is possible to work in the time domain and add more TGUARD dynamically, as synchronicity degrades during holdover. This will prolong holdover time at the expense of symbols used for data.**  **Observation 9: A higher UL SCS puts tighter requirements on UE initial timing accuracy.**  **Observation 10: Allocating a reasonably large part for channel delay spread we see that only very small cannel changes (small fractions of ±5 meters and even less) can happen if we want to maintain uplink timing within CP, for SCS = 960 kHz and higher.**  **Observation 11: Strict TA related requirements (for UE) are very important to maintain uplink timing within CP for high SCS. At SCS = 960 kHz requirements become very demanding. An SCS less than or equal to 480 kHz would make requirements less strict, but still demanding.**  **Proposal: Capture the following observation in TR 38.808: A higher UL SCS puts tighter requirements on UE UL timing and thus it is essential that the SCS selection and UE UL timing requirements are discussed jointly.** |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1

*Sub-topic description: Timing text proposals*

*Open issues and candidate options before e-meeting:*

**Issue3-1: Timing text proposals**

* Proposals
  + Option 1: Continue to discuss the text proposals in [**R4-2016036**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016036.zip)and[**R4-2016000**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip)to see if an acceptable single TP can be agreed
  + Option 2: Approve TP in [**R4-2016036**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016036.zip)
  + Option 3: Approve TP in [**R4-2016000**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip)
* Recommended WF
  + Option 1

**Issue 3-2: Timing proposals**

* Proposals
  + Option 1: Discuss proposals in [**R4-2016000**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip)during the meeting.
* Recommended WF
  + Option 1

## Companies views’ collection for 1st round

### Open issues

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| **Company** | **Comments** |
| Intel | Sub topic 3-1: Timing text proposal  We share most of observations in R4-2016000 and prefer option 3. We are okay for further alignment across companies to come up with a single TP (option 1) as well.  Sub topic 3-2: Timing proposals  Support option 1 |
| Ericsson | Sub topic 3-1: Option 1: Continue to discuss the text proposals in **[R4-2016036](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016036.zip)** and **[R4-2016000](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip)** to see if an acceptable single TP can be agreed.  Sub topic 3-2: Discuss proposals in R4-2016036 and R4-2016000 during the meeting. |
| Qualcomm | Issue 3-1: Option 1: Continue to discuss the text proposals in R4-2016036 and R4-2016000 to see if an acceptable single TP can be agreed.  Issue 3-2:   * The meaning of Proposal 1 is not clear. What timing requirements? * We agree with Proposal 3 to wait for RAN1 SCS. * Proposal 4 we want to hear other company view, but don’t agree at this point |
| Huawei | Issue 3-1 (Timing aspects proposals): Option 1, with the baseline in [R4-2016000](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip).  Issue 3-2 (Timing proposals from [R4-2016000](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016000.zip)):  Proposal 1: Maintain timing requirements related to the TDD guard periods.  Huawei: for SI we may capture some observations on timing aspects with potential technical topics to look at in future WI, but not firm decisions on requirements are needed.  Proposal 2: Improvement of TAE requirements shall be considered  Huawei: same as for Proposal 1. There are some assumptions on MIMO operation mode for the TAE - those assumptions may not be valid for all the use cases.  Proposal 3: Wait for RAN1 decision on sub-carrier spacings for SSBs before advancing on the initial timing requirements.  Huawei: basically we agree. RAN4 decision can be deferred to WI - there is no need to have concrete agreements on requirements in SI phase.  Proposal 4: RAN4 to apply scaling of UE timing accuracy in Table 7.3.2.2-1 in TS 38.133 for wider SCS in >52.6 GHz, similarly to what is currently specified for existing SCS values.  Huawei: not sure if RRM experts are following this discussion. This is WI area.  Proposal 5: RAN4 to study the adaptation of the autonomous time adjustment parameters, Tq and Tp, for larger subcarrier spacings at >52.6 GHz carrier frequencies.  Huawei: this is seen as WI area. |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

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| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |