**3GPP TSG-RAN WG4 Meeting #94-e R4-2002902**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 9.23

**Source:** Apple Inc.

**Title:** Email discussion summary for RAN4#94e\_#35\_NR\_n48\_LTE\_48\_coex

**Document for:** Information

# Introduction

Dynamic spectrum sharing is an important feature that allows for sharing existing spectrum between the LTE and NR carriers, thus enabling smoother transition from LTE and faster adoption of NR. After the RAN#86 meeting, a new WI was agreed aiming to analyse and introduce, if needed, changes to support dynamic spectrum sharing in band 48/n48 frequency range.

This document aims at capturing outcome of the email discussion focusing on required changes, if any, needed to support the aforementioned functionality. The following rounds are suggested:

- 1st round: collect company opinions on the required changes, if any;

- 2nd round: if applicable, proceed with draft CRs and/or WFs.

# Topic #1: LTE/NR spectrum sharing in band 48/n48

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2001386 | Ericsson | *Observation 1: NR SSB pattern C can fit into LTE 2 CRS ports with no subframe shift needed.**Observation 2: NR SSB pattern C would collide with LTE 4CRS ports with no subframe shift.**Observation 3: NR SSB pattern C can fit into LTE 4 CRS ports with 3 subframe shift when LTE subframes are configured as MBSFN subframes.**Observation 4: NR pattern B is not preferred as it will double the UE complexity to detect the SSB.**Observation 5: Band 48 in CBRS applies strict SFN which doesn’t allow subframe shifts.***Proposal 1: Do not apply 100kHz channel raster.****Proposal 2: Do not apply 7.5kHz sub-carrier shift in UL.****Proposal 3: Do not apply any change for the existing specifications.** |
| R4-2002048 | Google Inc. | *Observation 1: The DSS channel raster should be up to implementation.**Observation 2: The TDM transmission via MBSFN configuration for DSS mixed numerology transmission has no impact to the existing RAN4 specification.**Observation 3: The FDM transmission via inter-numerology guard band for DSS mixed numerology transmission should be up to implementation.**Observation 4: The 7.5KHz UL shift may not be required for the mixed numerology transmission.**Observation 5: To add or replace n48 SSB pattern may impact the initial search complexity and commercial timeline. The requirement for BS to change SCS in symbol level scale may be needed to define.* *Observation 6: The MBSFN configuration to avoid overlapping transmissions between NR SSB and LTE CRS has no additional impact to the existing RAN4 specification.* **Proposal: To enable the DSS between LTE band 48 and NR band n48, there should be no additional impact to RAN4 specifications.** |
| R4-2000086 | Apple Inc. | *Observation 1a: 300kHz raster does not require any further standardization changes and thus can be used by the SAS allocation entity to align LTE and NR centre frequencies for those carriers where DSS operation is needed.**Observation 1b: As opposed to 100kHz, 300kHz raster might result in less efficient spectrum utilization and/or spectrum re-allocation problems when an operator decides to enable the DSS functionality.***Proposal 1a: 300kHz channel raster can be viewed as a baseline option for spectrum sharing between LTE and NR.****Proposal 1b: 100kHz channel raster can ensure more efficient (dynamic) spectrum utilization in band n48.****Proposal 2: Consider adding 7.5kHz UL shift capability for band n48.***Observation 3a: NR sync pattern C can work with 1-2 port LTE deployments, but 4-port LTE CRS transmission will always collide with NR SSB.**Observation 3b: NR sync pattern B can work with 4-port LTE deployments.**Observation 3c: Since candidate LTE MBSFN sub-frames do not overlap with OFDM symbols where NR SSB is transmitted, LTE MBSFN cannot be considered as a viable solution to avoid overlaps (unless some further changes are introduced impacting other WGs).*Proposal 3: Adopt sync pattern B for band n48 definition. |
| R4-2000273 | Samsung | *Observation 1: for channel raster to enable DSS between LTE and NR 48/n48, the 300 kHz raster can be used as implementation approach without specification impact.* *Observation 2: one use case of UL 7.5 kHz shift is to resolve the non-orthogonal issue between LTE and NR in case of 15 kHz SCS of NR operation.**Observation 3: the legacy solution to avoid non-orthogonal interference for operation between LTE@15 kHz SCS and NR@30 kHz SCS in case of DSS is to adopt guard gap by implementation manner.* *Observation 4: MBSFN approach can be applied to resolved LTE CRS and NR SSB collision for TDD NR band refarmed from LTE to support DSS for all extensively used LTE TDD UL/DL configurations.* *Observation 5: MBSFN approach can be applied to resolved LTE CRS and NR SSB collision for FDD NR band refarmed from LTE to support DSS without any restriction on DL subframe configuration.* |
| R4-2001043 | Nokia, Nokia Shanghai Bel  | *Observation 1: 30 kHz SCS should be considered primarily for the deployment of n48.**Observation 2: The UL/DL configuration and timing shall be aligned and synchronized between NR and LTE to mitigate the UL/DL interference.***Proposal 1: It is proposed to further check which SSB block pattern(s) is suited for n48 to support band 48/n48 spectrum sharing.***Observation 3: There is no significant benefit to have the exact raster alignment between NR and LTE for the deployment of 30 kHz SCS in the NR.***Proposal 2: No change in the sync and channel raster is required.** |

## Open issues summary

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

### Channel raster

*Sub-topic description:*

**Issue 1-1: Channel raster**

- Proposals:

- Option 1: Keep existing 300kHz channel raster (no changes to the specifications);

- Option 2: Add 100kHz channel raster.

- Recommendation for further discussion:

- Based on the expressed observations and proposals, it seems that 300kHz raster can work, but the main concern is the resulting efficiency of spectrum utilization. It is suggested to delve further into analysing how much spectrum utilization might degrade if 300kHz raster is kept. CBRS operator and SAS operator feedback is appreciated.

### UL shift

*Sub-topic description*

**Issue 1-2: UL shift**

- Proposals:

- Option 1: A UE does not support UL 7.5kHz shift on band n48 (no changes to the specifications);

- Option 2: A UE supports UL 7.5kHz shift on band n48;

- Recommendation for further discussion:

- Based on the expressed observations and proposals, UL 7.5kHz is not considered as an essential feature for 30kHz SCS if a large inter-numerology guard band is always used. Companies/operators are welcome to provide further feedback so that 3GPP RAN WG4 can proceed towards the final conclusion

### Sync pattern

*Sub-topic description*

**Issue 1-3: Sync pattern**

- Proposals:

- Option 1: Keep existing pattern C (no changes to the specifications);

- Option 2: Keep existing pattern C and adopt LTE MBSFN;

- Option 3: Adopt pattern B;

- Recommendation for further discussion:

- Existing pattern C can be used if only 2-port LTE transmission are considered for the CBRS band, and thus further CBRS operator feedback is appreciated. Adopting LTE MBSFN approach will require shifting LTE and NR sub-frames, which will impact CBRS specifications and is likely to impact other RAN WGs. Thus, companies are welcome to provide further analysis on the potential specification impact. Switching to pattern B might increase cell search time, and thus UE vendors are welcome to provide further analysis on the resulting impact.

## Companies views’ collection for 1st round

### Open issues

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| --- | --- |
| **Company** | **Comments** |
| Ericsson | Sub topic 1-1: Support Option 1.Sub topic 1-2: Support Option 1.Sub topic 1-3: Support Option 1.Others: The current LTE and NR specifications support the dynamic spectrum sharing feature to be used for band 48/n48 by proper configurations so there is no need of changing any 3GPP specifications. All the objectives listed in this WI are achieved based on the current 3GPP specifications. |
| Samsung | Sub topic 1-1: option 1 should be applied with no impact existing SCS based channel raster for n48.Sub topic 1-2: Option 1 should be applied since no motivation to include 7.5KHz UL shift for n48 based on current condition. Sub topic 1-3: option 1 should be applied since the rate matching can be left for implementation.To summary, we also believe no RAN4 specification impact is needed to support DSS between 48/n48.  |
| Nokia | Issue 1-1 : Support Option 1Issue 1-2: Support Option 1Issue 1-3: Support option 3.Pattern C is not compatible when LTE is deployed with 4 port CRS. Downgrading LTE from 4 port to 2 port CRS will impact coverage and capacity (Eg. no 4x4 MIMO TM4) when enabling DSS. Additionally, DSS brings further overheads from NR which will further decrease the perceived capacity by LTE users. As indicated by moderator, switching to pattern B might increase (analysis are needed to prove this is the case) cell search time. However, pattern B would be still preferred due to coverage and capacity degradations. Cell Selection events are assumed not to be excessively frequent and multiband deployments would also reduce the impact of these along with UE stored information for last NR cell.Introducing LTE MBSFN with Pattern C, requires the support of MBSFN offset (RAN1 topic). Additionally, the offset would not allow for aligned TDD configurations for LTE and NR for all mandatory CBRSA TDD frame configurations, hence this solution is not an option for DSS on n48One possible solution is to enable optional support for the pattern B in addition to pattern C. |
| Qualcomm | Issue 1-1: Support option 1Issue 1-2: Support option 1Issue 1-3: Support option 1In R4-2000086 it was recognized that introduction of pattern B would cause a conflict with Band n77 which uses sync pattern C only. However, the paper suggests that since Band n48 is a US band and Band n77 is a European band, there would not be any actual conflict; i.e., the UE could use its location to narrow its search hypotheses. However, there is current consideration by the FCC to release C-band spectrum that could enable the use of n77 in the US. Therefore, it should not be assumed that n77 will not be used in the US.  |
| Huawei | Issue 1-1: OK with Option 1.Issue 1-2: If the main use case is with 30KHz data SCS, Option 1 is OK.Issue 1-3: Pattern C is more preferable since it can be aligned with n77/n78 design. Pattern C is also used for n90. Both Option1 and 2 are acceptable. |
| Charter Communications | Issue 1-1: Support option 2. We understand that Option 1 will only allow use of every third Band 48 channel for a maximum of four 10 MHz channels in the 3550-3650 MHz range. Clearly this is a problem. Channel assignment is controlled by the SAS and not the CBSD and depends on incumbent activity. Channel bonding to higher bandwidths is also not possible. Therefore, we support Option 2.Issue 1-2: Support option 1. We understand that while this shift is not required for NR@30kHz operations, a future introduction of support for DSS with NR@15kHz could benefit from this shift. Issue 1-3: Support option 1. While we believe introduction of Pattern B would alleviate this issue, it does bring up additional (valid) concerns of increased initial search complexity, additional power consumption, and might delay commercial availability. While a solution to that could be to introduce new UE capability or make one of the patterns (e.g. Pattern C) as the ‘default’ pattern to be supported by UE, and Pattern B as optional (which will limit the above referenced impacts to only UEs supporting only Pattern C), we understand that such an option will also introduce additional delays wrt commercial availability. So, we are okay with option 1.Qualcomm’s comment on C-band may not apply, as upon FCC’s ruling, a new band may have to be defined. |
| Comcast | Issue 1-1: Support Option 2.As Charter indicates, the lack of control of channels provided by the SAS implies we need 100KHz solution. Additionally, an implementation based option will imply operator specific shift in center frequency will be required, which implies lower spectrum utilization and increased requirements on the equipment and UE vendors to support non-traditional channel bandwidth and band combinations.Issue 1-2: Option 1 mandatory. Consider Option 2 optionalWe agree an UL shift is not required for 30KHz SCS, and existing industry guidance with CBRS-A only mandates 30KHz SCS so Option 1 is sufficient to support mixed numerology case. However as discussed in R4-2000086, there is a spectrum efficiency impact with supporting guard band and/or scheduling oversight needed, so we request Option 2 is also optionally supported in the specifications to allow vendor options to implement solution to support operator requirements.Issue 1-3: Support Option 1  |
| Apple | Issue 1-1: Even though it is possible to perform DSS between LTE and NR by configuring the center frequency on the 300kHz raster, it should be reminded that an operator cannot control and know in advance which spectrum chunk it will be allocated. As also mentioned by Charter Communications, channel assignment is controlled by SAS, not by CBSD. According to several examples in our discussion paper, if an operator receives a spectrum allocation, e.g. 20MHz, center frequency of which is not on the 300kHz raster, then it will not be possible to use DSS unless we shift the center frequency left/right effectively reducing that spectrum allocation. This is generally the reason why our view is that 100kHz raster should be further considered.Issue 1-2: If there is a common understanding that we always deploy only 30kHz SCS and that the inter-numerology guard-band will be always there, then we also agree that UL 7.5kHz shift is not needed. However, as spectrum allocation is controlled by SAS, there is no guarantee that in a particular scenario the allocation will be rather small, for which 30kHz SCS will result in a very poor spectrum utilization. From that perspective we would prefer to be future proof and make our specifications be ready to handle that case. If mandating UL 7.5kHz shift is not an acceptable option, we would also open to consider whether the system still can work if it is optionally supported by UEs.Issue 1-3: If the 4-port LTE transmission is still desired for band n48, then adopting pattern B would be the easiest and the most efficient solution. It seems that the main concern with adopting pattern B is “increased search time and power consumption”. As a general reminder, when a UE performs frequency band scan probing for all the frequencies it supports, the overall search time and power consumption will be anyway high for NR because a UE would probe not only for 2G/3G/4G, but also for the NR control signals. In that sense, scanning band n48 frequency range for both pattern C and B will not add much extra time or power consumption. The second important point is that it usually happens only once, e.g. after the cold start. Once a UE finds the serving operator cell, it start following re-selection rules; and it will know the band ID meaning that it will not have to test for all the possible hypotheses. |
| Google | Issue 1-1: Support option 1Issue 1-2: Support option 1Issue 1-3: Support option 1We prefer no changes to the specification in the current release. The initial search may be triggered frequently if a UE is out-of-service at the cell edge or in some pool signal areas. It may increase search time or power consumption for the UE with extra pattern B. We support to include C-band into consideration and we are not sure if there is a need to define a new band. The Band n77 requirements could be suggested to investigate if it is applicable to C-band or not. We also understand the spectrum allocation is controlled by SAS and the spectrum utilization might be poor in some cases for 30KHz SCS. Perhaps there could be more enhancement discussion in the future release.  |
| CableLabs | Issue 1-1: Support option 2Due to the analysis in R4-2000086, option 1 is spectrum inefficient. In addition, option 1 may impact PAL auction strategy. For example, the 10th 10-MHz channel will be 3641.8 to 3651.8 MHz that the higher portion of the channel from 3650 to 3651.8 MHz is no longer protected by the FCC PAL protection rules that only applies to 3550-3650 MHz.Issue 1-2: Support option 1Issue 1-3: Support option 1 |

### 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** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

For issue 1-1, 6 companies support keeping current 300kHz raster, 1 company is Ok to keep current 300kHz raster; three CBRS operators and OEM vendor raised a concern that 300kHz raster will prevent an operator from enabling DSS for NR and LTE because there is no guarantee that the allocated spectrum will be on the 300kHz raster. Due to the dynamic nature of spectrum allocated by SAS, the allocated spectrum chunk can be also on the 100kHz raster.

For issue 1-2, most companies expressed a preference not to mandate UL 7.5kHz shift. One CBRS operator and one OEM vendor suggested to explore further an option of making it optional for the UE side, i.e. some UEs may support it.

For issue 1-3, most companies expressed a preference not to do any changes, i.e. keep existing pattern C. One network-side vendor and OEM vendor raised a concern that it will effectively prohibit 4-port LTE transmission on band n48, which according to the network-side vendor opinion will decrease capacity and coverage.

### 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**  |
| **1-1** | *Tentative agreements:**Candidate options: 1) 300kHz raster (no changes to the spec); 2) 100kHz raster.**Recommendations for 2nd round: Proponents of 300kHz raster are encouraged to provide more input to the analysis of how DSS will work with band n48 allocations if we keep only 300kHz raster (in a situation when the actual allocation from SAS can be on any raster).*  |
| **1-2** | *Tentative agreements: UL 7.5kHz shift is not a mandatory UE feature for band n48**Candidate options: UL 7.5kHz shift is not mandatory UE feature, but its support is not precluded.**Recommendations for 2nd round: Proponents of the optional support of 7.5kHz UL shift will investigate and present further conclusions on the feasibility of this approach, i.e. whether it works and how.*  |
| **1-3** | *Tentative agreements:**Candidate options: 1) Keep existing pattern C (no changes to the specifications); 2) Keep existing pattern C and adopt LTE MBSFN; 3) Adopt pattern B (in addition to pattern C or replacing pattern C);**Recommendations for 2nd round: The first question to be answered is whether 4-port LTE deployments are considered for band n48 or whether we can make a conscious decision that they will be effectively precluded. If there is a common understanding that 4-port LTE deployments are still considered for band n48, then we should analyze further all the implications by adopting either LTE MBSFN and/or pattern B: for LTE MSBFN, the main concern is the specification impact including CBRS alliance; for pattern B, the main concern is the cell search time and power consumption.* |

*Recommendations 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 provides recommendation on CRs/TPs Status update*

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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

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

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| R4-2002854 (WF document) | During the second discussion round companies were providing more technical input to the open issues.1-1: Proponents of keeping 300kHz raster added further concerns on the specifications impact, such as general raster design principle and adding new GSCN entries. Proponents of adding new 100kHz raster kept emphasizing that spectrum allocation is not controlled by them, but by SAS entity. One SAS operator provided general input to the discussion noting that SAS entity has a number of limitations with regards to which chunk of spectrum can be allocated to a particular operator. No consensus was reached and R4-2002854 suggests a way forward for this topic.1-2: As the majority of companies prefer not to do any changes, Option 1 is suggested in R4-2002854 as a way forward.1-3: One CBRS band operator provided further input that 4-port LTE is a preferred deployment option. Proponents of keeping Pattern C added concerns that adding Pattern B would conflict with band n77 design and will increase cell search time and power consumption. No consensus was reached and R4-2002854 suggests a way forward for this topic.R4-2002854 is co-sourced by 4 companies (1 OEM vendor and 3 CBRS operators), 11 companies took part in the discussion.1 company expressed the following view: "*We still don’t agree with this WF.  We think that all specifications are already in place to support DSS in this band.  We recognize that there may be opportunities for optimization on a deployment-specific basis, but we think those can be left to implementation*". Several companies disagreed with this statement as it is not clear how e.g. the problem with the 4-port LTE transmission can be solved in the implementation specific way.**Moderator suggestion**: The WF captures all known (by the time when the discussion finished) pros and cons for open issues, sub-topics 1-1 and 1-3, and is a good baseline for further discussions.  |