**3GPP TSG-RAN WG4 Meeting # 104-e DraftR4-2214304**

**Electronic Meeting, 15– 26 August 2022**

**Agenda item:** 11.3

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [104-e][315] FS\_NR\_duplex\_evo

**Document for:** Information

# Introduction

This thread is on Rel-18 SI for Study on evolution of NR duplex operation. As this is the first meeting for RAN4 discussion, according to guideline from RAN4 leadership in R4-2114691, work plan should be discussed and concluded as a basis for organizing discussion. Besides discussion and clarification on RAN4 work scope, there are contributions submitted for RF feasibility with respect to co-channel self-interference, co-existence study on adjacent channel and regulatory aspect, which will be discussed under each topic. Meanwhile, the reply LS on interference modelling requested by RAN1 shall be discussed in this thread.

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

* 1st round: comment collected for each topic and conclude on work plan if possible
* 2nd round: WF and reply LS to be discussed according to 1st round discussion

It is appreciated that the delegates for this topic put their contact information in the table below.

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|  |  |  |
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Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)

# Topic #1: Work plan

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2212487 | Samsung, CMCC | Work plan from rapporteur companies according to SID approved in RP-221352. |
| R4-2212492 | Huawei, HiSilicon | **Observation 1**: the main tasks for RAN4 are feasibility study, the impact to RF requirements and considerations on the regulatory aspects on the concerned deployment cases. |
| R4-2212485 | Samsung | **Observation 1**: for gNB co-channel self-interference case, the RF impact on gNB perspective can be discussed further with the items/scenario in RAN1 LS as starting point.  **Observation 2**: for UE-to-UE co-channel inter-subband CLI, further discussion is needed dependent on SBFD subband configuration.  **Observation 3**: For gNB-to-gNB inter-cell co-channel inter-subband CLI, the gNB location will have impact on IC capability requested to ensure gNB co-channel co-existence.  **Observation 4**: for adjacent channel co-existence, whether enhancement is needed for gNB capable of SBFD operation needs further study.  **Observation 5**: the candidate method for CLI handling may have impact on feasibility and RF impact which needs further study dependent on RAN1 further conclusion. |

## 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:*

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

**Issue 1-1: Work plan**

* Proposals: work plan with scope on RF discussion for SI is provided in R4-2212487 for endorsement
* Recommended WF
  + Companies’ view, comment and/or clarification on work plan are encouraged.
  + If current version is not agreeable please elaborate specifically on how to update.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | As proponent company we suggest RAN4 endorse this Work plan as it is. |
| Spark NZ | Even during the Rel 18 workshop and subsequent meetings we raised the issue of regulatory compliance that involves the mitigation of interference between different operators. We suggest that the interference scenarios should include interoperator interference. Looking at the interference scenarios considered in this document only intra gNB and same operator inter gNB cases are considered. This will only apply when all the spectrum is given to a single operator. In the absence of synchronized deployment across all the band, the regulators may impose more stringent sharing criteria. |
| Nokia, Nokia Shanghai Bell | We do not agree with the proposed work plan as feasibility evaluation is missing from work plan completely. We suggest to focus first meetings to evaluate feasibility of RF requirements considering self-interference and different CLI components based on the detailed analysis of the technical background. Focus on LS reply should follow only after feasibility is confirmed, as otherwise we risk sending erroneous and misleading response to RAN1.    Following changes are needed for the first meetings and it would be good to re-evaluate the longer term work plan once the outlook is clearer based on the first couple of meetings.   |  | | --- | | **#104 meeting (0.25TU)**   * + Focus on ~~response LS from RAN1~~ impact and feasibility analysis of self-interference and CLI   + Start the analysis for co-existence study using CLI co-existence as starting point   + Endorse work plan | | **September 2022 RAN#97-e** | | **#104bis meeting (0.5TU)**   * + ~~Continue~~ Start response LS if any ~~open issues~~ conclusions on feasibility and impact   + Simulation assumption alignment for co-existence study   + Continue RF requirements feasibility and impact for self-interference/inter-subbands   **#105 meeting (0.5TU)**   * + Continue co-existence simulation assumption discussion   + Initial results for co-existence study   + RF requirements impact for self-interference/inter-subbands | |
| Qualcomm | As mentioned already, RAN4 is responsible for the feasibility study, the impact to RF requirements and considerations on the regulatory aspects related to SBFD deployments. RAN4 should start with providing its technical opinion on the raised question by RAN1 LS. RAN4 can use this as a starting point to kickstart the discussions on RAN4 responsibilities as agreed in the SID.  We agree on the points raised by Nokia regarding spilling out the focus on feasibility. However, we also should focus on providing a meaningful reply to RAN1 LS during this meeting. |
| Samsung | We believe that it’s straightforward that the feasibility study in RAN4 would continue through the whole SI phase as RAN4 scope. And no one will against this that’s why this is not explicitly mentioned in plan for each meeting. But as rapporteur company we do have concern on the revision from Nokia which aims to postpone discussion on reply LS to next meeting as this would have impact on RAN1 evaluation and SI progress. We would like to emphasize that there is clear note captured in SID agreed as below which should be respected:   * Note: RAN4 should be involved early to provide necessary information to RAN1 as needed and to study the feasibility aspects due to high impact in antenna/RF and algorithm design, which include antenna isolation, TX IM suppression in the RX part, filtering and digital interference suppression.   We agree that would be too optimistic to conclude all details requested in RAN1 LS. But we still should discuss in this meeting to conclude and reply as much as possible. |

## 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 #1-1: work plan** | *Tentative agreement:*  *To revise Work plan according to concern shared on the feasibility study as RAN4 fundamental task is not included in work plan explicitly.*  *Candidate option:*  *There are different views on whether reply LS should be discussed in this meeting. Considering there is already widely discussion in 1st round and whether LS to be replied is consensus based, it’s suggested to no update on LS related action in work plan.*  *Recommendations for 2nd round: Work plan to be revised in 2nd round according to tentative agreement* |

### CRs/TPs

*NA*

## Discussion on 2nd round (if applicable)

Comment to work plan revision directly.

# Topic #2: Feasiblity study and RF impact

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

## Companies’ contributions summary

### Reply LS on interference modelling for SBFD operation

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2211709 | CATT | **Observation 1: RAN1 would like to know BS/UE SBFD RF performance/capabilities and how to model them in the system simulation for several SBFD scenarios.**  **Observation 2: RAN4 can have the assumption in Table 1 for the input of SBFD discussion.**  **Proposal 1: RAN4 need to analyse if the Rx blocking issue is a problem for the intra-subband interference types.**  **Proposal 2: For gNB self-interference, inter-band CLI and adjacent channel CLI, at least the following two issues should be analysed in RAN4.**   1. **Victim Rx path is not blocked by the aggressor Tx band power.** 2. **Victim Rx band noise due to the aggressor Tx leakage.**   **Proposal 3: The reply to RAN1 can be step-by-step, the first step can be a preliminary model for calibration purpose. The exact model and the performance can be replied later.**  **Observation 3: The RAN4 conclusions for blocking issue would be two possible directions: 1) The blocking issue is severe to make SBFD not feasible. 2) The blocking issue can be solved with xdB () SNR degradation to victim Rx band.**  **Proposal 4: For the blocking issue, RAN4 can reply the two possible conclusion directions to RAN1 to arrange the further simulation work.**  **Observation 4: For residual Tx leakage issue, RAN4 may need more time to discuss the performance and the simulation model than the blocking issue.**  **Proposal 5: ACIR model in TR 36.942 can be a reference model for RAN1 simulation calibration purpose.** |
| R4-2211562 | Qualcomm CDMA Technologies | **Proposal 1: Agree within RAN4 to utilize RAN1 RSI metric when studying the feasibility of SBFD deployment. RSI represents the ratio between gNB Tx power on an DL RB *m* and the gNB residual self-interference on a single receiver chain at UL RB *n* caused by DL transmission on DL RB *m*, which is represented in dB as .**  **Proposal 2: RAN4 to agree on the value range of 80-90 dB of spatial isolation via be based on two panels configuration with split of the antenna elements for simultaneous downlink transmission and uplink reception.**  **Proposal 3: RAN4 to agree on approximating the frequency isolation gNB’s capability with RAN4 gNB ACLR requirements, which equals to 45 dB, 28 dB, and 26 dB for FR1, FR2-1, and FR2-2, respectively.**  **Proposal 1: The frequency isolation could be approximated as flat, non-frequency selective profile and its value per-RB is .**  **Proposal 5: RAN4 to agree on the value range of 5-10 dB for beam nulling and clutter mitigation for FR1 and FR2 SBFD deployments.**  **Proposal 6: RAN4 to agree on the value range of 10-15 dB for residual self-interference cancellation in the digital domain for FR1 and FR2 SBFD deployments.**  **Proposal 7: RAN4 to agree on the value range of the aggregate self-interference** **mitigation RSI of 140-150 dB (120-140 dB) for FR1 (FR2) as shown in Table 1.**  Table 1 Aggregate self-interference mitigation budget   |  |  | | --- | --- | |  | Mitigation capability for FR1 (FR2) | | Ant. isolation | 80 dB (80-90 dB) | | Freq. isolation (ASLR) | 45 dB (28 dB) | | Tx/Rx beam nulling or beam isolation | 5~10 dB (5~10 dB) | | Digital IC | 10~15 dB (10 dB) | | *RSI* | 140~150 dB (120-140 dB) |   **Proposal 8: RAN4 to adopt gNB ACLR and ACS requirements to model co-channel inter-gNB CLI.**  **Proposal 9: For co-site inter-sector inter-gNB CLI, self-interference mitigation capability should be assumed for CLI mitigation in order to ensure successful reception of the UL signals at the victim gNB.**  **Proposal 10: RAN4 to discuss developing multiple gain-state model with input power dependent noise figure for RAN1 and possibly RAN4.**  **Proposal 10: RAN4 to reply to RAN LS with the draft LS provided in Section 5 in this contribution.** |
| R4-2211880 | Apple | ***Proposal 1: For UE-UE co-channel inter-subband CLI modeling of TX unwanted emission, use the in-band emission requirement in 38.101-1 (FR1) and 38.101-2 (FR2).***  ***Proposal 2: For UE-UE co-channel inter-subband CLI modeling of RX selectivity/blocking, use the current maximum input level specified in RAN4 as a threshold:***   * ***If inter-subband interference is higher than the threshold, it is assumed it will result large receiver degradation and hence the RX will not correctly decode the data*** * ***For inter-subband interference that is smaller than the threshold, treat the blocker as interference, i.e. consider a dB-to-dB increase of interference due to blocker power***   ***Proposal 3: For UE-UE adjacent-channel CLI modeling of TX unwanted emission, use the two ACLR level model shown in Fig. 3.***  ***Proposal 4: For UE-UE adjacent-channel inter-subband CLI modeling of RX selectivity/blocking, use the following model:***   * ***If the blocker is higher than -25dBm, it is assumed it will result large receiver degradation and hence the RX will not correctly decode the data*** * ***For the blocker that is smaller than -25dBm, use the ACS values to calculate the resulting interference***   ***In addition, consider a 5dB SNR degradation due to receiver gain backoff*** |
| R4-2212117 | Kumu Networks | In this paper, we presented a joint RF cancellation and beam-nulling approach for self-interference mitigation in SBFD systems. We evaluated our approach through simulations showing >100dB isolation achievable with minimal impact on beamforming gains and the number of RF cancellers scaling linearly with the number of antennas in the system. The simulations incorporate different antenna configurations and channel multipath effects and found the proposed solution to be robust to both. We have also demonstrated the efficacy of this system with a smaller scale hardware prototype using Kumu Networks’ RF cancellation chip. |
| R4-2212160 | MediaTek (Chengdu) Inc. | Proposal 1: For co-channel Aspect 1, indicate to RAN1 that it is feasible to model UE Tx emissions per RB by modelling the minimum required IBE requirements specified in 38.101-1 and 38.101-2.  Proposal 2: For co-channel Aspect 2, indicate to RAN1 that there are no UE in-channel selectivity minimum requirements today, so concrete assumptions about existing UE performance cannot be made. However, the ICI and power imbalance aspects should be considered in any co-channel Rx modelling by RAN1.  Proposal 3: For adjacent channel Aspect 1, indicate to RAN1 that:   * for adjacent channel UE Tx emissions, the UE SEM is applicable as a per-RB/sub-band measure for UEs at maximum output power. At lower output power levels, it is not possible to make concrete assumptions about relative leakage on per-RB/sub-band level, but ACLR dictates the maximum allowed average leakage across the channel. * ACLR is only appropriate for modelling “average” emission impacts across the ACLR measurement bandwidth of the channel. It should not be assumed that the average ACLR would accurately model UE emission behaviour if averaged per-RB/sub-band. Also indicate that ACLR inherently includes a guardband.   Proposal 4: For adjacent channel aspect 2, indicate to RAN1 that:   * there are no per-RB/sub-band related requirements defined, so one cannot make concrete assumptions on existing UE selectivity performance on a per-RB/sub-band level * ACS can only be used to identify statistical average impact across a channel |
| [R4-2212312](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104-e/Docs/R4-2212312.zip) | CMCC | **Observation 1: Target SI cancelation ratio should be 148dB for WA, 128dB for MR and 111dB for LA.**  **Observation 2: per PRB basis RSI is more preferred to facilitate RAN1’ simulation and scheme design.**  **Observation 3: it seems more reasonable to show one SI value range to reflect overall SI suppression capability. If necessary, we could add some examples of separate estimates for different means under the overall value range assumption.**  **Observation 4: for gNB without sub-band filter for SI cancellation, RSI could be simplified as frequency flat at least for FR1. But for gNB with sub-band filter, the attenuation mask is not flat unless defining larger transition guard band.**  **Observation 5: it’s feasible to consider Tx leakage and Rx selectivity as described in RAN1’s LS for inter-sub band CLI. Besides, blocking issue should also be carefully studied for co-site scenario.**  **Proposal 1: it’s suggested to further check whether legacy ACLR limit of gNB is also applicable for inter-sub band case or not.**  **Observation 7: for inter sub-band CLI, the main differences between co-site inter sector and inter site scenarios include following two aspects:**   * **Antenna isolation of co-site inter-sector is near-field antenna characteristics but for inter-site, antenna isolation is far-field antenna characteristics.** * **For co-site scenario, digital interference cancellation could be utilized. But for inter-site scenario, there is no possibility for such digital interference cancellation.**   **Proposal 2: It’s better to reuse legacy IBE requirements for evaluation.**  **Observation 8: two options are listed to avoid UE-UE inter-sub band interference based on the assumption that legacy UE could also work in SBFD network.**   * **Option 1: RAN4 collect minimum requirements from UE vendors that could reflect all legacy UE’s Rx selectivity for inter-sub band case and reply it to RAN1 for their simulation and scheme design.** * **Option 2: RAN4 send the LS to RAN1 and ask RAN1 design schemes to avoid UE-UE inter-sub band interference with 0dB Rx inter-sub band selectivity requirements** |
| R4-2212486 | Samsung | The UL reception SINR formula for gNB with SBFD operation is summarized as below:  Where  And the Interferenceother is interference from surrounding system(s) includes below cases which is applicable for certain scenario      For victim UE DL reception with UE UL interference the SINR formula is summarized as below:  Where the Interferenceother is fromvictim UE transmission as below  And the RSIC, ASBIR, and ACIR are provided in table 1, table 2 and table 4 respectively.  Table 1: value range of RSIC   |  |  |  | | --- | --- | --- | | **Parameter** | **FR1** | **FR2** | | Spatial isolation | 70 -80 dBc | 90-120 dBc | | Frequency isolation | 45 dBc | 30 dBc | | Beam nulling /isolation | ~10 dBc | ~5 dBc | | Digital IC | 30-50 dBc | 30 -50 dBc | | Overall RSIC capability | 140 – 185 dBc | 145 - 205 dBc |   Table 2: ASBIR (adjacent sub-band interference ratio) candidate for co-channel inter-subband CLI   |  |  |  |  | | --- | --- | --- | --- | | **Frequency range** | | **Inter-site gNB-gNB** | **UE-UE** | | **FR1** | Candidate 1 | 43dBc | 28dBc | | Candidate 2 | 20+dBc | 20+dB | | **FR2** | Candidate 1 | 22.5dBc | 16.5dBc | | Candidate 2 | ~14dBc | ~14dB |   Table 4: ACIR   |  |  |  | | --- | --- | --- | | **Frequency range** | **Inter-site gNB-gNB** | **UE-UE** | | FR1 | 43dBc | 28dBc | | FR2 | 22.5dBc | 16.5dBc | |
| R4-2212492 | Huawei, HiSilicon | **Observation 2**: for self-interference, the RX receiver blocking and reference sensitivity degradation should be evaluated. |
| R4-2212493 | Huawei, HiSilicon | *Moderator summary according to the LS draft*:  For BS self-interference cancellation link budget provided as below table with  Table 2.1-1 link budget for RSI   |  |  |  | | --- | --- | --- | | Parameters | FR1 Macro | FR2 Macro | | Tx power (dBm) | 49 | 38 dBm/400M | | Spatial isolation (dB) | 80 | 85~95 | | TX beam isolation (dB) | 10 | 10 | | Blocking level at receiver chain (dBm) | -41 | -63/100M | | Frequency isolation ACLR (dB) | 45 | 28 | | RX beam isolation (dB) | 10 | 10 | | Digital cancellation (dB) | 10 | - | | Overall suppression (dB) | 145 | 123 | | REFSENS degradation (dB) | < 1 | < 1 |   Co-channel inter-subband CLI:   |  |  |  | | --- | --- | --- | | CLI interference | Transmitter perspective | Receiver perspective | | gNB-gNB (co-site and inter-site) | ACLR | In-band blocking | | UE-UE | IBE | 0dB since no subband filter | | ACLR if subband filter applied | ACS if subband filter assumed |   Adjacent-channel CLI  gNB-gNB (co-site and inter-site): TX ACLR and RX ACS can be used in the simulation. Tntenna gain would be different for wanted signal and unwanted signal. Hence separate calculation from ACLR and ACS perspective is more accurate.  UE-UE: if we assume the directivity is the same for wanted signal and unwanted signal for UE, the ACIR ratio can be adopted |
| R4-2212599 | Xiaomi | **For gNB self-interference:**  **Observation 1: the lowest measured isolation is from configuration IV if the same distance is considered for all the configurations.**  **Observation 2: 30dB minimum coupling loss (MCL) is assumed for both WCDMA, LTE and NR FR1 for co-side BS when defining transmitter intermodulation requirement.**  **Observation 3: the in-band emission improved from UE side and current ICS requirement from BS side could be as a reference when deriving the frequency isolation.**  **For gNB-gNB/ UE-UE co-channel CLI:**  **Observation 4: the two aspects are very similar to transmitter part and receiver part in Frequency isolation as mentioned above in the gNB self-interference case especially for gNB-gNB co-channel CLI case, thus they could be discussed together.**  **For gNB-gNB/ UE-UE adjacent-channel CLI:**  **Observation 5: the two aspects for gNB-gNB/ UE-UE adjacent-channel CLI could be reflected by ACIR，the granularity shall be for FFS.** |
| R4-2212619 | Ericsson | **Proposal 1:**  **For UE specific parameters, RAN4 should use the existing UE RF specification and extrapolate the needed parameters for system level studies.**  **Proposal 2:**  **For system level and co-existence studies, it is proposed to use the existing requirements and the corresponding existing reference carrier bandwidth granularity.**  **Proposal 3:**  **For link level, interference cancellation and evaluation studies, RAN4 should consider finer needed granularity when transmitter and receiver models are being developed.**  **Proposal 4:**  **RAN4 should develop realistic models for transmitter and receiver impairments for further evaluation of SBFD.**  **Proposal 5:**  **BS characteristics based on a BS just meeting gNB minimum RF requirements should be used as a base-line for SBFD feasibility studies. From this, modelling of improved performance can be considered if needed.**  **Proposal 6:**  **RAN4 should consider the models and means to achieve the required suppression separately for each BS class.**  **Proposal 7:**  **RAN4 should develop realistic models for high antenna isolations and define how isolation based on different evaluation need should be specified.**  **Proposal 8:**  **Multi-carrier behaviour of gNB should be considered when evaluating DL and UL RF impairments and cancellation schemes.**  **Proposal 9:**  **Energy efficiency of gNB should be considered when evaluating SBFD and cancellation schemes.**  The annex proposes a reply LS to RAN1 based on the initial state of RAN4 discussions.  **Proposal 10:**  **RAN4 should send the draft LS response in this paper as the first stage of providing answers to questions stated in the LS on interference modelling for duplex evaluation.** |
| R4-2212802 | vivo | **Proposal 1: For the interference study in RAN4, these in-channel and adjacent channel RF metrics in Table 1 can be used as the baseline for full duplex.**  **Proposal 2: RAN4 provide a single range for RAN1 considering the overall self-interference suppression capability for BS.**  **Observation 1: For wide area BS, the self-interference suppression value is estimated as 112 dB according to current BS dynamic range. （assuming DL 40M+UL 20M+DL 40M configuration）**  **Proposal 3: For subband transmission at gNB side, discuss whether BS ACLR can apply for adjacent subband.**  **Proposal 4: RAN4 to discuss the guard bands between adjacent subbands for full duplex.**  **Proposal 5: Reuse BS ICS at the receiver side for gNB-gNB co-channel inter-subband CLI.**  **Proposal 6. Use UE IBE as a starting point at Tx side for UE-UE co-channel inter-subband CLI.** |
| R4-2212848 | Nokia, Nokia Shanghai Bell | ***Observation 1: Different implementations in terms of output power, MIMO and beamforming capabilities need to be considered in feasibility evaluation.***  ***Observation 2: SBFD cannot be operated without changes to RF architecture and as such SBFD needs new physical implementations and cannot be software upgraded to existing and deployed base stations.***  ***Observation 3: SBFD operation using shared antenna for Tx and Rx does not appear to be feasible.***  ***Observation 4: Impact of reflections from clutter needs further work.***  ***Observation 5: gNB RF architecture based on separate Tx and Rx antennas results in***   * ***Inferior performance in case total antenna area is kept equal*** * ***Significant increase in cost, size and weight in case antenna area is increased to avoid performance loss*** * ***Permanent loss of reciprocity even if antenna area is increased***   ***Observation 6: SBFD results in increased power consumption compared to static or dynamic TDD***  ***Observation 7: Analog interference cancellation in the circuit board does not appear feasible at least in case multiple antenna elements are used, which is the case in nearly all commercial base stations.***  ***Observation 8: Dynamic range and linearity of Rx front-end needs to be taken into account in addition to direct Tx ACLR contribution when analysing feasibility of SBFD operation.***  ***Observation 9: More than 100 dB of isolation from Tx antenna(s) to individual Rx antenna is required to avoid desensitization of the receiver in a typical FR1 macro scenario.***  ***Observation 10: Required antenna-to-antenna isolation scales dB-to-dB with transmit output power and sensitivity.***  ***Observation 11: Impacts from blockers and IIP2 need to be further analyzed.***  ***Observation 12: In case no degradation of UE performance is desired for SBFD use cases, the physical separation (> 200 m) or coupling loss (>90 dB) between aggressor UE and victim UE need to be very large.***  ***Observation 13: If worst case UE ACLR performance is considered, ACLR contribution to the in-band noise at the receive input seem to be the strongest contribution compared with IMD3 contributions.***  ***Observation 14: The unwanted emissions at the gNB are currently modelled with the adjacent channel power leakage (ACLR). An extension of the ACLR for adjacent sub-bands in the same carrier, namely the inter-subband leakage ratio (ISLR), can be used to model the unwanted emissions for SBFD gNBs. This assumes there is suffiency frequency separation between 2 sub-bands of opposite link direction.***  ***Observation 15: The new inter-subband selectivity (ISS) defines the gNB receiver selectivity with finer frequency granurality as compared to existing gNB adjacent channel selectivity requirements.***  ***Observation 16: For modelling the co-channel inter-subband CLI, the inter-subband interference ratio (ISIR) is proposed. The ISIR resembles the existing ACIR requirement but it is defined with finer granurality.***  ***Observation 17: For adjacent channel inter-subband CLI, the existing BS ACIR requirements can be extended for SBFD simulations. Finer frequency granurality in the ACIR assumptions could be needed.***  ***Observation 18: The current UE in-band emission model can be applied for modelling the UE unwanted emissions on SBFD.***  ***Observation 19: No ICS requirements are defined for the UE. Existing UE ACS requirements could be applied with finer frequency granurality.***  ***Observation 20: For adjacent channel inter-subband CLI, the existing UE ACIR requirements can be extended for SBFD simulations. Finer frequency granurality in the ACIR requirements could be needed.***  ***Observation 21: For FR1 UMa simulations, SBFD is shown to provide a >2x improvement in the UL coverage/5%-ile UE UL throughput performance as compared to static TDD, if assuming a ratio of self-interference (RSI) of at least 148 dB or more (45 dB ACLR + 80 dB analog suppression + scaling factor).***  ***Observation 22: For FR1 UMa simulations, UL spectral efficiency of SBFD is generally worse than with static TDD (60%-16% worse depending on the RSI) since half the amount of transmit and receive antennas is used for SBFD.***  ***Proposal 1: Sufficiently large gain under realistic assumptions should be observed from SBFD as compared to fixed and dynamic TDD to justify the complexity of introducing support for SBFD.***  ***Proposal 2: Regarding gNB self-interference modelling for system level simulations, principles for the model for UE in-band emissions (IBE) in TS 38.101-1, Section 6.4.2.3 can be used as a starting point for modelling the frequency-separation dependency of the gNB self-interference between an aggressor and victim RB/SC.***  ***Proposal 3: With respect to question 1-3 from the RAN1 LS R1-2205543 on ‘Whether it is possible to simplify the RSI as frequency flat model, and under which condition(s) the dependency of the RSI on frequency can be ignored?’:***   * ***a fixed value of can be assumed (for any (m,n) RB pair) if there is sufficient separation or guard band between UL and DL subbands/RBs such that the UL RB are placed only on the ‘flat region’ of the DL emission mask.***   + ***Under the additional assumption of fixed gNB transmit power density (i.e. gNB transmit power varies depending on number of allocated RBs), the accumulated interference from all DL RBs towards a victim UL RB n can be simplified as follows:***      - ***wherein,***       * ***is the transmit power per RB***       * ***is the total number of allocated DL RBs at a given time***     - ***Note: This model is conditioned on sufficient (analog) isolation between Tx-Rx such that the receiver still operates in linear region. If not the case, intermodulation products will be dominant which may introduce some frequency dependent components making the presented model not valid***   ***Proposal 4: For the modelling of intra-site inter-subband inter-sector interference, reuse the same model as for self-interference but replacing with a new parameter expressing the overall isolation between Tx and Rx across co-located sectors A and B, including spatial isolation, beamforming, etc.***   * ***Considering that the major sources of inter-sector interference are due to the radiation via sidelobes and back lobes of the gNB antenna, can be assumed to be higher or at least equal to .***   ***Proposal 5: Use the answers provided in this section (section 7) in the reply LS to RAN1.*** |
| [R4-2213690](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104-e/Docs/R4-2213690.zip) | ZTE Corporation | *Moderator summary according to LS draft:*  RSI analysis has been provided for FR1 and FR2 gNB respective. And the <1dB de-sensitivity should be met at least dependent on BS implementation to enable SBFD operation.  For co-channel CLI case, two options provided from transmitter perspective. And only flat ACS model provided for receiver perspective.  For adjacent channel CLI case, two options provided from transmitter perspective. And only flat ACS model provided for receiver perspective.  It’s suggested to focus on sub-band or carrier level granularity without further study on interference model in finer granularity to facilitate discussion. |
| R4-2213692 | ZTE Corporation | **Observation 1:** for FR1 full duplex BS, the following approach could be used to handle the self-interference:   1. Antenna isolation from transmitter to receiver; 2. Sub-band filtering of transmitter to further reject the leakage into the receiver; 3. ACLR of transmitter which is mainly determined by the PA performance and digital filtering implemented for DL; 4. Sub-band filtering of receiver to reject the power from the transmitter; 5. ACS of receiver to reject the power from the transmitter by digital filtering; 6. Digital interference cancellation at receiver; 7. RF interference cancellation;   **Observation 2:** for FR2 full duplex BS, the following approach could be used to handle the self-interference:   1. Antenna isolation from transmitter to receiver; 2. ACLR of transmitter which is mainly determined by the PA performance and digital filtering implemented for DL; 3. ACS of receiver to reject the power from the transmitter by digital filtering; 4. Digital interference cancellation at receiver; 5. RF interference cancellation;   **Observation 3**: it seems feasible to support the full duplex operation for Medium range BS.  **Proposal 1** : for FR1 full duplex BS, to consider the self interference mitigation approaches as mentioned in table 2.2.1-1 to different BS class supporting the full duplex operation and its detailed value could be further studied.  **Proposal 2**: for FR1 full duplex BS, to check the feasibility from both refesens degradation and LNA blocking perspective.  **Observation 4**: it seems feasible to support the full duplex operation for Wide area BS with only the antenna isolation considered.  **Proposal 3** : for FR2 full duplex BS, to consider the self interference mitigation approaches as mentioned in table 2.2.2-1 with the removal of sub-band filtering to different BS class supporting the full duplex operation and its detailed value could be further studied.  **Proposal 4**: for FR2 full duplex BS, to check the feasibility from both refesens degradation and LNA blocking perspective. |

### Adjacent channel co-existence study

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2211561 | Qualcomm CDMA Technologies | **Proposal 1: For FR1, support UMa with 500m ISD and InH as baseline deployment scenario for subband non-overlapping full duplex evaluation. Consider Uma with large percentile of UEs indoor to investigate extreme inter-UE CLI.**  **Proposal 2: For FR2, support UMa with 200m ISD for FR2-1 and InH for FR2-1 as baseline deployment scenarios for subband non-overlapping full duplex evaluation.**  **Proposal 3: For FR1, support UMi as optional deployment scenarios.**  **Proposal 2: For FR2, support UMi with 100m ISD for FR2-1, InH for FR2-2 and IAB as optional deployment scenarios.**  **Proposal 5: In SBFD deployments, inter-gNB and inter-UE CLI results from the leakage to adjacent subband.**  **Proposal 6: For co-located gNBs, the current RAN4 30 dB isolation is not sufficient to address the inter-gNB CLI. For current ACLR and ACS RAN4 requirements, inter-gNB isolation in the ballpark of 80 dB is required for feasible SBFD deployments.**  **Proposal 7: For co-site inter-sector inter-gNB CLI, self-interference mitigation capability should be assumed for CLI mitigation in order to ensure successful reception of the UL signals at the victim gNB.**  **Proposal 8: Inter-gNB coupling loss can be evaluated utilizing existing gNB-UE channel models in TR 38.802/38.901 with the proper adjustments on deployment and antenna parameters to mimic a gNB-gNB scenario.**  **Proposal 9: gNB ACLR requirements provide a measure of Tx leakage on the adjacent channel. As a starting point for FR1 and FR2-1, 45 dB and 28 dB ACLR, respectively, as defined in RAN4 specs may be used.**  **Proposal 10: gNB ACS requirements provide a measure of Rx selectivity on the adjacent band, which can be assumed valid for inter-subband selectivity. As a starting point for FR1 and FR2-1-, 46 dB and 24 dB ACS, respectively, as defined in RAN4 specs may be used.**  **Proposal 11: For inter-site inter-sector inter-gNB CLI, RAN4 to adopt gNB ACLR and ACS requirements (i.e., Adjacent channel interference ratio per subband).**  **Proposal 12: Agree on the simulation parameters provided in Table 1 for RAN4 coexistence work** |
| R4-2211710 | CATT | **Observation 1: The four adjacent channel interference scenarios for SBFD were simulated in dynamic TDD. The difference for SBFD is that one of the aggressor and victim is changed to sub-band.**  **Proposal 1: RAN4 should discuss and decide if co-existence simulation should be conducted for SBFD adjacent channel co-existence.**  **Proposal 2: Some typical sub-band parameters assumption, such as RB number, guard band, filter, etc, should be discussed and decided for RAN4 further discussion.**  **Observation 2: The co-located BS-BS interference analysis for SBFD is the same with dynamic TDD, i.e. if blocking requirement for gNB is not changed, aggressor Tx power will block victim Rx path.**  **Proposal 3: RAN4 should decide if co-located scenario should be supported or if BS blocking requirement can be more stringent for SBFD SI.** |
| R4-2212161 | MediaTek (Chengdu) Inc. | Regarding system level simulation (SLS) activities for the Duplex Enhancements SI, RAN4 to recommend to RAN#97-e that, due to the likely overlap, co-channel and adjacent channel system level analysis for this specific SI should be carried out purely by RAN1, with RAN4 providing relevant modelling information, as requested in [2].  Failing that, we would propose to hold off further SLS development in RAN4 until further clarification at RAN#97-e. |
| R4-2212313 | CMCC | **Observation 1: legacy ACLR/ACS limits will lead to performance degradation for macro gNB- macro gNB scenario for both FR1 and FR2. But as long as care is taken with some solutions, in other scenarios, legacy ACLR and ACS limits may still apply.**  **Observation 2: legacy ACLR/ACS limits still apply for UE-UE CLI scenario for FR2. For FR1, legacy ACLR/ACS limits still applies for most scenarios except for macro->indoor, for which scenario, as long as care is taken with some solutions, legacy ACLR and ACS limits may also apply.**  **Proposal 1: 4GHz and 30GHz are suggested as example frequency for FR1 and FR2 respectively.**  **Proposal 2: Deployment scenarios for adjacent channel evaluation are as below for FR1.**   * **urban macro and indoor as the baseline**   + **We can only focus on the scenario that legacy limits not applicable as verified in R16 CLI to reduce workload.** * **dense urban scenario with 1 layer (micro) or 2-layer (macro + micro) scenarios are optional, if companies contribute to them, final simulation results should also be considered.**   **Proposal 3: Deployment scenario for adjacent channel evaluation are as below for FR2**   * **urban macro, indoor and urban micro all as the baseline**   + **We can only focus on the scenario that legacy limits not applicable as verified in R16 CLI to reduce workload.**   **Proposal 4: we should at first model ACLR equivalent emission mask for legacy TDD carrier to help calculate received sub-band interference at adjacent SBFD carrier.**  **Observation 3: some options to model ACLR equivalent emission mask among adjacent channel for legacy TDD.**   * **Option 1: frequency flat among adjacent channel** * **Option 2: reuse OBUE spectrum model but scaling the limit so that total emission power among adjacent channel equal to ACLR value.**   **Proposal 5: we should define ACLR1, ACLR2 and even higher order ACLR model for SBFD network to help evaluate interference.**  **Observation 4: simulation assumption for FR1 is listed in table 3.** |
| R4-2212494 | Huawei, HiSilicon | ***Observation 1: Refer to the conclusion in TR 38.828, no/limited performance degradation can be observed under Indoor scenarios.***  ***Proposal 1: For Rel-18 duplex co-existence evaluation:***   * ***Macro scenario shall be treated as high priority for both FR1 and FR2;*** * ***RAN4 Rel-16 CLI study’s conclusion can be reused for indoor scenario. Thus such scenario shall be treated as low priority for both FR1 and FR2.***   ***Proposal 2: Consider the following scenarios for Rel-18 duplex co-existence evaluation:***   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | FR | Scenario  No. | Deployment Scenario  (Aggressor -> Victim) | Aggressor baseline (adjacent channel) | Aggressor  (adjacent channel) | Victim | | 1 | 1 | Urban  Macro → Macro | 100MHz NR TDD  DL | 100MHz NR SBFD  1:4 UL:DL | 100MHz NR TDD  DL | | 2 | 100MHz NR TDD  UL | 100MHz NR SBFD  1:4 UL:DL | 100MHz NR TDD  UL | | 3 | 100MHz NR SBFD  1:4 UL:DL | 100MHz NR TDD  DL | 100MHz NR SBFD  1:4 UL:DL | | 4 | 100MHz NR SBFD  1:4 UL:DL | 100MHz NR TDD  UL | 100MHz NR SBFD  1:4 UL:DL | | 2 | 5 | Urban  Macro → Macro | 200MHz NR TDD  DL | 200MHz NR SBFD  1:4 UL:DL | 200MHz NR TDD  DL | | 6 | 200MHz NR TDD  UL | 200MHz NR SBFD  1:4 UL:DL | 200MHz NR TDD  UL | | 7 | 200MHz NR SBFD  1:4 UL:DL | 200MHz NR TDD  DL | 200MHz NR SBFD  1:4 UL:DL | | 8 | 200MHz NR SBFD  1:4 UL:DL | 200MHz NR TDD  UL | 200MHz NR SBFD  1:4 UL:DL |   ***Proposal 3: The 100% grid shift shall be applied for evaluation, while 0% grid shift doesn’t need to be considered.***   * ***Further discuss on whether to consider other grid shift value.***   ***Proposal 4: Consider two types of UE distribution for the co-existence evaluation regarding Macro scenario:***   * ***Option 1 (Basic option since this is reuse of TR 38.828):***    + ***Random and uniform UE dropping. 20% outdoor in cars: 30km/h and 80% indoor in houses: 3km/h.*** * ***Option 2:***    + ***Step 1: Randomly drop a cluster within a macro cell geographical area considering the minimum distance between macro TRP to cluster centre, e.g., 100m , where the size of each cluster is 120 x 50 (m);***   + ***Step 2: 80% UEs are randomly and uniformly dropped within the cluster, and 20% UEs are randomly and uniformly dropped outside the cluster.***   ***Proposal 5: On the BS antenna configuration assumption for legacy TDD operation:***   * ***For FR2, reuse the BS antenna configuration in TR 38.828 clause 5.2.2.5;*** * ***For FR1, discuss on how to choose between the following two types of BS antenna configuration:*** * ***Alt. 1: The BS antenna modelling captured in TR 38.828 clause 5.2.1.5;*** * ***Alt. 2: The BS antenna modelling extension defined in TR 38.803 clause 5.2.3.2.4.***   ***Proposal 6: Further discuss on how to determine the SBFD BS antenna configuration between following two options:***   * ***Option 1: The total number of antenna elements of the antenna array for SBFD is the same as the total number of antenna elements of the antenna array for legacy TDD.*** * ***Option 2: The total number of antenna elements of the antenna array for SBFD is two times of the total number of antenna elements of the antenna array for legacy TDD.***   ***Proposal 7: Adopt [49 dBm] for FR1 and [38 dBm] for FR2 BS Tx power assumption.***  ***Proposal 8: Reuse the FR1/FR2 BS noise figure assumption in TR 38.828 for legacy TDD BS, further discuss on the value of this parameter for SBFD BS.*** |
| R4-2212621 | Ericsson | **Proposal 1:**  **Estimate UE performance based on existing UE RF requirements and if needed extrapolated for system level studies.**  **Proposal 2:**  **RAN4 to use FR1 UE transmit requirements discussed in this section for system level studies and LS response to RAN1**  **Proposal 3:**  **RAN4 to use UE SEM requirement of -25 dBm or ACLR 30dB for LS response to RAN1.**  **Observation 1:**  **The -25 dBm / MHz or ACLR can be pessimistic and thus UE vendors to provide more detailed analysis for possibly lower value if needed.**  **Proposal 4:**  **RAN4 to use UE blocking requirements discussed in this section for system level studies and LS response to RAN1.**  **Proposal 5:**  **RAN4 to use UE ACS requirements discussed in this section for system level studies and LS response to RAN1.**  **Observation 2:**  **There is a need to further discuss FR2 system parameters for SBFD study.**  **Proposal 6:**  **RAN4 to use BS ACLR and operating band unwanted emission as baseline and extrapolate the requirements taking into account the additional guard between DL transmission of the aggressor and UL reception of the victim and different aggressor / RX sub-band bandwidths for adjacent channel system studies discussed in this section.**  **Proposal 7:**  **RAN4 to use BS receiver blocking as baseline for adjacent channel system studies discussed in this section. Further work is needed to establish acceptable interferer levels that will not cause noise floor degradation in the receiver.**  **Observation 3:**  **Additional receiver aspects such as receiver linearity can influence the interference for adjacent channel studies and should be considered depending on the interfere level and deployment.**  **Observation 4:**  **Measurements of physical passive antennas for different set ups indicate isolation level of 40-50 dB for co-located antennas.** |
| [R4-2212697](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_104-e/Docs/R4-2212697.zip) | Samsung | **Proposal 1**: The RAN4 shall conduct co-ex study as the co-ex study will be the discussion basis for RAN4 to:   * Determine the supporting co-ex scenarios for SBFD operation; * Check the adjacent channel interference with existing ACIR (ACLR/ACS) requirements in SBFD operation; * Check the feasibility of new ACIR (ACLR/ACS) requirements for new SBFD-capable gNBs.   **Observation 1**: The adjacent channel co-existence study can focus on the timeslot(s) where the aggressor SBFD having its subband UL and DL operating simultaneously while the victim legacy TDD system is in its DL timeslot(s). The rest timeslot(s) are legacy TDD co-existence cases, and the adjacent channel interference (ACI) of those cases were solved by legacy ACLR and ACS of each frequency range already.  **Proposal 2**: Proposed to consider both SBFD Subband configuration#1 with {DUD} pattern, which means one SBFD slot consists of one UL subband at the center of the channel bandwidth and two DL subbands at two sides of the channel bandwidth, and SBFD Subband configuration#2 with {DU} pattern, which means one SBFD slot consists of one UL subband at one side of the channel bandwidth and one DL subband at the other side of the channel bandwidth, in RAN4 co-ex study. These two configurations are shown in figure below:     1. (b)   Fig.2 SBFD subband configurations: (a) #1 {DUD}, (b) #2 {DU}  **Observation 2**: The results from TR 38.828 reflects the cross-link adjacent channel interference impact focused on the FR1 and FR2 Macro-Macro case for BS-BS interference link, and FR1 Macro-Indoor case for UE-UE interference link. And RAN1 agreements also shows they will focus on Macro cases as starting point.  **Proposal 3**: Considering Observation 1 and 2, we propose RAN4 to consider the following scenarios in Table 2 as the starting point for SBFD co-ex study with legacy TDD system.  Table 2. SBFD adjacent channel co-existence scenarios (starting point)   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | FR | Scenario  No. | Deployment Scenario  (Aggressor -> Victim) | Aggressor baseline | Aggressor | Victim | | 1 | 1 | Macro -> Macro | NR, 100MHz, DL ACI | NR, 100MHz SBFD1 | NR, 100MHz, DL | | 2 | Macro -> Macro | SBFD Intra-system | NR, 100MHz, DL | NR, 100MHz SBFD1 | | 3 | Macro -> Indoor | NR, 100MHz, DL ACI | NR, 100MHz SBFD1 | NR, 100MHz, DL | | 4 | Macro -> Indoor | SBFD Intra-system | NR, 100MHz, DL | NR, 100MHz SBFD1 | | 2 | 5 | Macro -> Macro | NR, 200MHz, DL ACI | NR, 200MHz, SBFD2 | NR, 200MHz, DL | | 6 | Macro -> Macro | SBFD Intra-system | NR, 200MHz, DL | NR, 200MHz, SBFD2 | | Note 1: For FR1, consider subband config#1 with {DUD}: 40MHz DL + 20MHz UL + 40MHz DL and subband config#2 with {DU}: 80MHz DL + 20MHz UL.  Note 2: For FR2, consider subband config#1 with {DUD}: 50MHz DL + 50MHz UL + 100MHz DL and subband config#2 with {DU}: 150MHz DL + 50MHz UL. | | | | | |   **Proposal 4**: Propose to adopt the system characteristics, deployment parameters and other assumptions from TR 38.828 as the starting point for SBFD co-ex study. But the assumptions should be updated accordingly to fulfill the SBFD co-ex purpose.  **Proposal 5**: Our understanding is that the SBFD BS could 1) utilize half of its original panel for DL and UL each, or 2) the SBFD BS could implement an extra panel with same number of elements for subband UL receiving so that the subband DL Tx will utilize same elements as legacy TDD BS. Thus, it is proposed for the meeting to consider two options for SBFD BS antenna and TRP power:   * Option 1: Utilize half of its original panel for SBFD UL and DL each. In this case, the TRP and elements number for DL and UL in SBFD BS will be half of the TDD BS configuration. * Option 2: Utilize an extra panel for subband UL operation. In this case, the TRP and element number for DL and UL in SBFD BS will be the same as TDD BS configuration.   **Proposal 6**: Propose to consider two options of SBFD BS power and elements based on what was assumed TR 38.828, while the victim legacy TDD BS assumption stays the same. The detailed proposed changes for SBFD BS can be found in the highlighted part of above tables.   |  |  |  | | --- | --- | --- | |  | FR1 Macro Urban | FR2 Macro Urban | | BS antenna configurations | For Legacy TDD:  (Mg,Ng,M,N,P)=(1,1,8,8,2) (dH,dV)=(0.5,0.8)λ  For SBFD:  Option 1: (Mg,Ng,M,N,P)=(1,1,4,8,2) (dH,dV)=(0.5,0.8)λ  Option 2: (Mg,Ng,M,N,P)=(1,1,8,8,2) (dH,dV)=(0.5,0.8)λ | For 30 GHz legacy TDD: (1, 1, 8, 16, 2)  For SBFD:  Option 1 (1, 1, 8, 8, 2)  Option 2 (1, 1, 8, 16, 2) | | BS Tx power | For Legacy TDD:  49 dBm  For SBFD:  Option 1: 46 dBm  Option 2: 49 dBm | For legacy TDD:  43dBm  For SBFD:  Option 1: 40 dBm  Option 2: 43 dBm |   **Proposal 7**: Propose to align the mechanical down-tilt angles assumptions for BS. And it is proposed to use 6 degrees for the Macro BS for FR1 and FR2 as provided in TR 38.803.  **Proposal 8**: Propose to use the following as the general uplink power control model for SBFD co-existence study.   |  | | --- | | For downlink scenario, no power control scheme is applied.  For uplink scenario, TPC model specified in Section 9.1 TR 36.942 [9] is applied with following parameters.  - CLx-ile = –SNR\_target + UE\_maxpower – ThermalNoise – BS\_NoiseFigure + 10\*log10(BW)  - γ = 1  Where, SNR\_target for FR1 and FR2 are 15 dB. |   **Proposal 9**: For FR1, it is proposed to adopt ACLR1 as 30 dBc and ACLR2 as 43 dBc for FR1 UE.  **Proposal 10**: Propose to adopt the following steps, modified from TR 38.828 and other general legacy RAN4 coex study report, as the simulation steps for SBFD coex study.   |  | | --- | | 1. Aggressor and victim network are generated.  - UEs are distributed randomly across the network.  2. UE associations: UEs are associated to base station based on coupling loss.  - Associations are made assuming a single element at both UE and BS.  3. Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-UE. This is done for both victim and aggressor networks.  4.  When legacy TDD system is victim, follow steps 4a:  4a. Throughput is computed considering ACI from another static TDD system as baseline aggressor:  - , where is the inter-cell interference and is the adjacent channel interference from the baseline aggressor.  When SBFD system is victim, follow steps 4b:  4b. Throughput is computed in the victim system without considering ACI as below:  - , where is the inter-cell interference.  5. Throughput is computed considering ACI below:  - , where is the adjacent channel interference. |   **Proposal 11**: It is proposed to follow the TR 38.828’s evaluation criteria to check the 50% and 5% throughput loss compared to the baseline scenario as described in table 2 (Proposal 3).  **Proposal 12**: In the above step 4b and 5, when SBFD is victim system, it is proposed to use {N = noise floor + 1dB} for the SBFD system to simulate the self-interference impact as a simplified method to evaluate its SINR/throughput.  **Observation 3**: The CLI SINR and Throughput distribution of our simulation platform seems quite aligned with the results in TR 38.828.  **Observation 4**: Our initial results shows the existing ACIR (ACLR/ACS) provides sufficient interference reduction in adjacent band legacy TDD. The performance degradation is below the evaluation criteria proposed in Proposal 11. |
| R4-2212801 | vivo | **Observation 1. For the gNB-gNB adjacent channel CLI co-existence, the interference from legacy BS can follow current ACLR/ACS model.**  **Observation 2: For SBFD channel, the adjacent channel leakage depends on the SBFD configuration.**  **Observation 3. The interference due to ACS is also dependent on the SBFD configuration.**  **Proposal 1: RAN4 decides SBFD configuration in the adjacent channel co-existence study.**  **Observation 4: For gNB supporting SBFD configuration (e.g. DL+UL+DL), if it transmits at DL subbands with its maximum power, the PSD for total DL transmission could boost.**  **Proposal 2: RAN4 to discuss the power assumption at DL subbands for gNB supporting SBFD configuration.**  **Proposal 3: For UE-UE adjacent channel CLI, RAN4 can discuss how to apply ACLR/ACS to the subband level.** |
| R4-2212847 | Nokia, Nokia Shanghai Bell | ***Proposal 1: Sufficiently large gain under realistic assumptions should be observed from SBFD as compared to fixed and dynamic TDD to justify the complexity of introducing support for SBFD.***  ***Observation 1: Both gNB-to-gNB and UE-to-UE adjacent channel CLI are present in SBFD operation.***  ***Observation 2: From a co-existence perspective, differences between SBFD and dynamic TDD operation are minor during non-aligned slots.***  ***Observation 3: Due to the dynamics in dynamic TDD, it is expected that there are less mis-aligned slots when dynamic TDD is used as compared to SBFD.***  ***Proposal 2: Unless there are meaningful differences in the deployment scenarios and/or used parameters, the conclusions done for dynamic TDD in TR 38.828 apply also for SBFD operation.*** |
| R4-2213691 | ZTE Corporation | **Proposal 1**: to study the following three coexistence scenario in the adjacent channel:   1. Full duplex BS coexisting with full duplex BS in the adjacent channel; 2. Full duplex BS coexisting with legacy TDD DL in the adjacent channel; 3. Full duplex BS coexisting with legacy TDD UL in the adjacent channel;   **Proposal 2:** to further checked the feasibility of following coexistence scenarios highlighted in orange in Table 2.2-1 and Table 2.2-2.  **Proposal 3:** to further study the coexistence scenario in Table 2.3-1 and Table 2.3-2 to investigate the impacts on full duplex BS.  **Proposal 4:** to usethe simulation assumption in TR 38.828 as baseline for full duplex coexistence study and further discuss the antenna pattern and related power for FR1 BS and FR2 BS due to the separate Tx and Rx antenna array assumption. |

### Co-channel RF feasibility study

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2212146 | Intel Corporation | **Proposal 1**: Since the CLI interference is large enough to potentially degrade the BS Rx SNIR, we propose to perform link-level simulations which will more precisely capture the adjacent channel leakage due to RF front-end non-linearities.  **Proposal 2**: We propose RAN4 to conduct further study into feasible levels of Tx-Rx antenna isolation.  **Proposal 3**: For the Full Duplex simulation effort, we would propose to agree on a PA model that includes a realistic DPD component |
| R4-2211711 | CATT | **Proposal 1: The SBFD discussion for FR1 and FR2 should be separated.**  **Proposal 2: SBFD discussion doesn’t impact current non-SBFD BS RF requirements, such as blocking requirements, etc. Whether SBFD BS defines new requirements depends on the further discussion in SBFD study.**  **Proposal 3: The following two capabilities should be discussed together for SBFD gNB self-interference Rx blocking issue.**   * **SBFD BS Rx blocking capability at Tx subband** * **Self-interference cancellation capability at Tx subband**   **Proposal 4: The SIC capability at Tx sub-band is divided to the following three domains for further discussion.**   * **Propagation domain SIC capability at Tx sub-band** * **Analog domain SIC capability at Tx sub-band** * **[Digital domain SIC capability at Tx sub-band]**   **How to reply RAN1 such as total capability or separate capability can have some flexibility.**  **Observation 1: SIC capability for Rx blocking issue may mainly rely on the propagation and analog domain techniques.**  **Proposal 5: RAN4 should decide if BS Tx SB filter should be used for the Tx leakage performance evaluation.**  **Observation 2: Some techniques based on the known Tx signal may not work well for SIC at Rx SB.**  **Proposal 6: The SIC capability at Rx sub-band is divided to the following three domains for further discussion.**   * **Propagation domain SIC capability at Rx sub-band** * **Analog domain SIC capability at Rx sub-band** * **Digital domain SIC capability at Rx sub-band**   **How to reply RAN1 such as total capability or separate capability can have some flexibility.**  **Proposal 7: The Rx blocking analysis assumption for inter-subband CLI, such as layout model, gNB parameters, UE parameters, etc, should be decided before the further discussion.**  **Proposal 8: The analysis assumption for gNB and UE subband Tx leakage performance should be discussed and decided, such as implementation architecture.**  **Proposal 9: The Rx blocking analysis assumption for intra-subband CLI, such as layout model, gNB parameters, UE parameters, etc, should be decided before the further discussion.** |
| R4-2211790 | CEWiT | Not available |
| R4-2212620 | Ericsson | **Observation 1:**  **It is not necessary to perform link level simulations using separate models for DPD and PA.**  **Proposal 1:**  **Adopt a net effect model that captures the essential behaviours of a realistic DPD and PA combination with compliance to the base station ACLR requirements.**  **Proposal 2:**  **Adopt a simple crest factor processing model, e.g., hard clipping + bandpass filtering, that captures the essential behaviours of a BS design to increase transmit power. This requires input from RAN4.**  **Observation 2:**  **There are several receiver imperfections which in combination with high power level in DL sub-band can highly affect the SBFD receiver.**  **Proposal 3:**  **Receiver impairments should be modelled and considered for SBFD link level and self-interference studies.**  **Proposal 4:**  **3GPP existing BS receiver requirements should be used as base-line and if needed extrapolated to derive models for link level and self-interference and feasibility studies.**  **Proposal 5:**  **The 6 dB sensitivity degradation of existing BS receiver requirements is too high considering UL coverage enhancement as one key benefit of SBFD. The analysis should consider 0.1 dB and 1 dB degradation instead.**  **Proposal 6:**  **The BS receiver non-linearities and selectivity that can reasonably be achieved should be modelled and investigated when evaluating SBFD and its feasibility.**  **Proposal 7:**  **The receiver reciprocal mixing of phase noise should be modelled and investigated when evaluating SBFD and its feasibility.**  **Observation 3: Simple physical separation cannot provide enough isolations between RX and TX with reasonable separation distances. A maximum isolation of ~40 dB seems possible with reasonable separation of ~4** **λ**.  **Observation 4: EBG structure in combination with physical separation provides 60-65 dB of isolations but over limited bandwidth.**  **Observation 5:**  **Dielectric absorber slabs in combination with physical separation provide isolation around 65 dB but is not a recommended solution for SBFD antennas due to passive intermodulation (PIM) and environmental variation aspects.**  **Observation 6:**  **Choke structure in combination with physical separation provide isolation around 60-70 dB but is bandwidth limited.**  **Observation 7:**  **Combination of different structures can provide reasonable isolation of 65 dB over large enough bandwidth.**  **Observation 8:**  **SBFD antenna performance highly depends on polarization and desired bandwidth and complexity of combined structures. In addition, the achievable isolation can degrade up to 10-15 dB depending on the beam forming over steering range of the antennas.**  **Proposal 8:**  **For link level assessment of SBFD, proper modelling of advanced antennas as well as modelling of beamforming impact on isolation should be considered.**  **Observation 9:**  **SBFD inter-gNB antenna isolation performance highly depends site installation and achievable isolation can vary significantly depending on the beam forming over steering range of the antennas.**  **Proposal 9:**  **For link level and system level assessment of SBFD for both co-channel and adjacent channel CLI, proper modelling of inter-gNB isolation as well as modelling of beamforming impact on isolation should be considered.**  **Observation 10:**  **Measurements of physical passive antennas for different set ups indicate isolation level of 40-50 dB for co-located antennas.**  **Proposal 11:**  **It is proposed to adopt the antenna parameters in this document for far field antenna pattern modelling during the SBFD studies.** |

## Open issues summary

RAN1 evaluation may be pending on RAN4 input on interference modelling for SBFD operation. To avoid potential impact on RAN1 progress due to lack of proper model, it’s suggested to prioritize the discussion on reply LS to RAN1 during this meeting. And input from companies will be merged under sub-topic 2-1 for all reply LS related discussion. And the remaining sub-topics on co-channel feasibility, adjacent channel co-existence and RF impact discussion will not handle related issues which already have been included in sub-topic 2-1 to avoid overlapping/redundant discussion. But the conclusion in sub-topic 2-1 would be considered as applicable for other sub-topics. Furthermore, even if tentative agreement concluded to be delivered RAN1, it's not precluded further discussion in RAN4.

### Sub-topic 2-1: reply LS on interference modelling for SBFD operation

LS from RAN1 in R4-2211510 is to request RAN4 to provide interference modeling for SLS on SBFD operation with three aspects as:

* Self-interference modelling for gNB capable of SBFD operation
* Co-channel inter-subband CLI modelling on gNB-gNB and UE-UE
* Adjacent-channel CLI modelling on gNB-gNB and UE-UE

Under sub-topic 2-1 it aims to collect view and invite discussion according to proposals provided from companies’ input for each aspect.

#### Issue 2-1-1: baseline in SBFD operation

* Proposal to gNB
  + Option 1: If found feasible, SBFD operation requires new/enhanced implementation for gNB capable of SBFD and cannot be software upgraded to existing BS
  + Option 2: SIC model is based on gNB implementation with existing BS RF requirement for gNB capable of SBFD
  + Option 3: No impact on requirement applied to existing gNB or gNB not capable of SBFD operation.
* Proposal to UE
  + Option 1: Estimate UE performance based on existing UE RF requirements and if needed extrapolated for system level studies
  + Option 2: Large physical separation or coupling loss between UEs is needed
  + Option 3: TBA
* Criteria on gNB UL receiver sensitivity degradation due to self-interference:
  + Option 1: minus 1dB degradation
  + Option 2: minus 0.1dB degradation
  + Option 3: required total RSIC for gNB SBFD operation is dependent on gNB output power and sensitivity level
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | * Proposal to gNB:   Option 1 and option 3 are OK for us. About option 2, we are not sure. Maybe some existing RF requirements should be more improved. For example, legacy ACLR requirement is not applicable for macro-macro co-existence between SBFD and legacy TDD network. if so, SIC model may be based on gNB implementation with better RF requirements to avoid interference.  Proposal to UE:   * Option 1 is OK for us. we should make sure legacy UE could works under SBFD network.   Option 2 may restrict actual network deployment, we should try to avoid use such distance isolation method and have higher priority for other methods. Option 2 may be the last solution to avoid interference.   * Criteria on gNB UL receiver sensitivity degradation due to self-interference:   Normally, we use minus 1dB degradation to evaluate interference, so option 1 is OK for us.  About option 3, we think criteria on gNB receiver sensitivity degradation is independent on gNB output power. Even if gNB has larger output power, it doesn’t mean such gNB could be able to bear larger interference. |
| Xiaomi | Proposal to UE:   * Option 1, the legacy UE should not be impacted and the approach on restriction of UE distance isolation is not realistic. |
| Ericsson | Regarding “proposal to gNB”, our understanding is that SBFD operation clearly requires a new/enhanced implementation of gNB:   * An antenna structure is required that isolates TX and RX whilst not compromising the far-field behaviour * RX performance likely needs to be beyond the minimum 3GPP requirement to avoid blocking * TX performance meeting the minimum 3GPP requirement is an option. However, it may be desirable to implement a TX that is somewhat better than the minimum requirement for ACLR etc., as this improves isolation and the required performance of interference cancellation in the receiver * Digital interference cancellation of the residual TX interference has been proposed as a means to further increase isolation. Quite possibly cancellation of interferences arising in the receiver may need to be considered too * In some contributions, analogue cancellation (or in the case of Kumu networks contribution, reduced complexity analogue cancellation) is proposed.   There is not any absolute need for a change on the emissions requirements towards other nodes (i.e. ACLR etc.). It is also OK to take the performance of a transmitter meeting emissions requirements as a baseline. As mentioned however, increasing the transmitter performance is another way to improve isolation and should be considered further.  At least for wide area gNB, it is likely that the receiver performance will need to be improved over the performance needed to meet the current 3GPP requirements (the receiver would be blocked by self-interference)  So we would propose an option 4: “Assume gNB implementation that meets 3GPP requirements as a baseline, but consider feasibility and gains from improved transmitter and receiver performance”  Option 3 is not exclusive to the other options and we agree option 3 too.  Regarding “proposal to UE”, we agree that the estimated UE performance based on existing requirements is a good baseline since the aim is clearly not to impact UEs. In case UE performance is not good enough to avoid UE-UE CLI then obviously there would need to be a consideration of what performance enhancement would be needed. As a first step though sending information to RAN1 based on performance of UEs meeting minimum requirements is the right way forward.  Regarding sensitivity degradation, it may be useful to agree on a degradation level from self-interference. It is worth to consider that, for a DDDSU pattern, the ceiling for the maximum possible coverage gain if there are no degradations is 7dB. Considering that there may be other degradations in addition to self-interference (interference from other nodes, redued antenna aperture, loss of reciprocity etc.) the aim should probably be to keep self-interference to below 1dB. It could be useful to assess feasibility of both 0.1dB and 1dB self-interference degradation.  Regarding the values proposed in the table:  For spatial isolation, it needs to be clarified whether the quoted isolation is element-element, sub-array-sub-array, panel-sub-array or panel-panel. Also of interest is the bandwidth over which the isolation is achieved; some techniques (e.g. RF chokes) achieve isolation over a relatively narrow bandwidth, whereas others achieve isolation over a wider bandwidth. For a cost-effective implementation, the bandwidth over which TX suppression can be achieved needs to be wide enough that the SBFD carrier can be configured anywhere within the band. Apart from that, our investigations suggest that the isolation depends on the beam steering direction at TX and RX. In general, for isolation over a reasonable bandwidth, by combining techniques for achieving isolation our EM simulations suggest an isolation of around 70dB is achievable for a beam in boresight over a reasonable bandwidth. With beam steering, this isolation may increase or decrease by 10dB. RAN4 should consider further the impact of beam steering.  For frequency isolation, assuming 45dB ACLR is a reasonable starting point. Actually, many contributions assume a 45dB difference in PSD between the DL and UL parts. The RAN4 ACLR requirement is actually based on defined carrier bandwidths, not PSD. As an approximation, assuming 45dB PSD difference is probably Ok though. On the other hand, improving TX emissions suppression could be a less complex alternative than relying only on digital cancellation techniques, in particular for cross-sector interference and so we think that assuming current BS performance is OK for a baseline, but considering improvements in TX performance over the current performance should not be ruled out.  For beam nulling, our observation so far is that the degrees of freedom to create the far field beam are compromised, and so it is not so obvious that the beam nulling improvement does not come at the expense of degrading coverage elsewhere. Also, if beam nulling is intended to suppress intra-array interference, then nulling in the near field needs to be simulated with EM simulations. Before deciding values, it should be clarified how/whether the nulling works in the near field and the impact to the far field patterns.  For digital IC, the IC needs to cancel all transmitter impairments, including non-linear effects such as clipping etc.. It needs to take into account all TX-RX paths within the array. Also, it may well need to be capable of cancelling RX impairments. Furthermore, for a complexity, size, weight and energy efficient BS, the BS transmitter and receiver will need to operate on multiple carriers, which cause a more complex signal to cancel. To assess the feasibility and possibility of digital IC, more detail is needed on the detailed signal structure to be cancelled before values can be concluded.  In the tables of suppression values, there are currently no RX impairments. Our observation is that for receivers meeting current requirements, the receivers would be blocked. Even if not blocked, for WA BS, the receivers would need a significantly improved IIP3 performance (in ther order of 0dBm) than receivers meeting current requirements. For MR BS, the receiver impairment may be less significant for receivers meeting current requirements but should be investigated further. |
| China Telecom | * Proposal to gNB: Option 1. New/enhanced implementation for gNB capable of SBFD is required to support multiple SIC methods. * Proposal to UE: Agree with Option 1. Legacy UE should not be affected. |
| Samsung | * Proposal to gNB: we support option 1 and option 3. They should be baseline assumption for this SI. And option 1 we agree that enhancement is needed for SBFD capable BS but also feasibility is one of the most important item in SI scope for RAN4. I suppose no one can deny those assumptions. * Proposal to UE: We fully support that at least for legacy UE should be supported in transparent way for SBFD operation. Hence existing UE RF requirement should be referred in the discussion. Hence option 1 is supported by Samsung. And regarding option 2, as this seems also never considered in legacy CLI study, it may not be put such restriction on the UE location now. * Criteria on gNB UL receiver sensitivity degradation due to self-interference * Option 1 is widely used in legacy ran4 study and also RF requirement discussion. Hence we support this option for the purpose of self-interference SLS. We should distinguish the discussion on feasibility and subsequent discussion on potential RF requirement impact. * For option 3, the self-interference falling in the own reception subband is derived based on TX power –RSI, this level should result in 1dB(if agreed) degradation on sensitivity. That why we support this option also. |
| Apple | Proposal to UE   * We support Option 1. Option 2 can be further discussed pending the coexistence analysis and the CLI mitigation solutions discussed in RAN1. |
| Huawei | Proposal to gNB  Option 1 and Option 3  Existing BS RF requirements may not reflect the BS capability. Hence we think Option 1 is ok.  Proposal to UE  Option 1 since we need to support legacy UE  Criteria on gNB UL receiver sensitivity degradation due to self-interference:  Option 1 can be used as starting point |
| Intel | Proposal to gNB  Option 1: SBFD operation requires new gNB features to include:   * Separate antenna panels. Splitting antenna on the same antenna panel will not achieve sufficient isolation * Improved Rx blocker handling, since the current spec is not that tight compared to many other RF receivers * Digital interference cancellation * Analogue interference cancellation   Proposal to UE  Option 1: Using legacy UE, estimate performance to evaluate what SBFD options are feasible  Criteria on gNB UL receiver sensitivity degradation due to self-interference:  Option 1: minus 1dB degradation |
| ZTE | **Proposal to gNB**  Based on the previous study, option 1 is reasonable assumption and it should have the impacts on the existing gNB or gNB not capable of SBFD, this is also quite clear.  **Proposal to UE:**  For option 1, since we need to follow the legacy TDD UE RF, then it is quite straight forward to reuse the existing RF requirements  For Option 2, this is part of coexistence study for CLI between UE UL and UE DL, this could be further discussed in details from both system level evaluation and link budget calculation if necessary.  **Criteria on gNB UL receiver sensitivity degradation due to self-interference:**  In high level, we can go with option 1, otherwise the RSIC should be very high which will cause much more implementation difficulties at end and this might be not necessary to have option 2. |
| Vivo | • Proposal to UE  We support Option 1 considering SBFD capable gNB should also serve the legacy UEs without new UE requirements.  For option 2, we expect that UE-UE co-channel inter-subband CLI can be further studied based on existing UE RF requirements. Also, interference level can be also addressed by assuming gNB’s proper scheduling. It is not clear how the restriction proposed in option 2 can be assumed in term of UE RF requirements as well as SBFD feature design. |
| CATT | **Proposal to gNB**  Option 1 and option 3. SBFD needs a whole new solution for BS.  **Proposal to UE:**  Option 1 is reasonable. Option 2 view needs some justification such as simulation, etc.  **Criteria on gNB UL receiver sensitivity degradation due to self-interference:**  Option 1 can be a starting point. |
| Nokia, Nokia Shanghai Bell | For proposals to gNB, we agree with option 1 and option 3, which also are not mutually exclusive.  For option 2, the overall feasibility of digital SIC needs further discussion taking into account different antenna sizes as well as which methods are considered to be applicable and what potential side-effects they bring. For example, if beam nulling is considered to be applicable for SIC, on top of what is the level of suppression achievable via this method there needs to be analysis on possible impact on wanted beams.  For proposal to UE both option 1 and option 2 are ok.  For the sensitivity degradation, the criteria will likely differ whether blocker signals are considered. Currently, ACS and in-band blocking cases allow 6 dB of sensitivity degradation, and it would be unreasonable to require only 0.1 dB or 1 dB degradation for the same case for SBFD capable base station. It is necessary to evaluate self-interference also under blocking conditions. Furthermore, it is necessary to evaluate impact from both CLI as well as self-interference. |
| Qualcomm | Proposed to gNB:  Support options 1 and 3. In addition, once RAN4 agrees on the feasibility of SBFD operation, some existing RF requirements might need to be revisted (e.g., ACLR and ACS for SBFD operation, gNB-to-gNB isolation requirement for co-located deployments, etc.) for SBFD-capable gNBs. Proposal to focus on feasibility of the proposed SIC capabilities by different companies.  Proposed to UE:  Support option 1. RAN4 to analyze the impact of SBFD deployment on the defined UE RF requirements. For SBFD deployments, legacy UEs should be supported in transparent way with the current existing RF requirements.  Criteria on gNB UL receiver sensitivity degradation due to self-interference:  Support option1. RAN4 to agree on 1 dB degradation criteria on gNB UL receiver sensitivity degradation due to self-interference. |
| MediaTek | Proposal to UE: Option 1 should be the baseline given that it is important not to impact legacy UE performance. Option 2 seems more like a potential outcome of the study item rather than an input parameter. |
| Kumu Networks | Proposal to gNB: Option 1 as SBFD would need new implementation to avoid losing coverage area. |

#### Issue 2-1-2: Self-interference modelling for Gnb capable SBFD operation

* Proposal from company according to factors requested by RAN1 for FR1 and FR2-1(Question 1-2).

Table 2-1-1: Summary table for FR1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Factors | R4-2211562 | R4-2212493 | R4-2212486 | R4-2212620 | R4-2212848 | R4-2213690  For Medium range BS | R4-2212117 |
| Spatial isolation | 80 Db  Separated panel | 80Db | 70 -80 Db  Separated panel | 65Db in large enough BW | 100+ Db needed for Macro, feasibility FFS , | 50Db | >70Db |
| Frequency isolation | 45 Db | 45 | 45 Db | - | 45Db  With guard band | 45Db | 45Db |
| Beam nulling /isolation | 5~10 Db | TX beam:10Db  RX beam:10Db | ~10 Db | - | FFS | - | +3Db on top of beamforming isolation |
| Digital IC | 10~15 Db | 10db | 30-50 Db | - | FFS | [30] for digital IC or transmitter sub-band filtering |  |
| Overall RSIC | 140~150 Db  as capable | 145Db | 140 – 185 Db as capable | - | 100+ Db needed for Macro | 125Db | >100Db |

Table 2-1-2: Summary table for FR2-1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | R4-2211562 | R4-2212493 | R4-2212486 | R4-2212848 | R4-2213690 |
| Spatial isolation | 80-90 Db  Separated panel | 85~95 | 90-120 Db  Separated panel | Shared antenna is not feasible | 96Db |
| Frequency isolation | 28 Db | 28Db | 30 Db | 22.5Db | 28Db |
| Beam nulling /isolation | 5~10 Db | TX beam:10Db  RX beam:10Db | ~5 Db | FFS |  |
| Digital IC | 10 Db | - | 30 -50 Db | FFS |  |
| Overall RSIC | 120-140 Db | 123Db | 145 – 205 Db | - | 124Db |

* =
* Proposal on granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5):
  + Option 1: RSI can be modelled as frequency flat and scaling to subband level
  + Option 2: RSI can be modelled as almost frequency flat and scaling to RB level
  + Option 3: Frequency flat model can be assumed with possible guard band reserved between subband pending on implementation
  + Option 4: A frequency flat model can be used, as long as sufficient guard band is assumed between DL and UL sub-bands.
* Proposal on RSI dependency on Blocking and AGC（Question 1-4）
  + Option 1: The in-band blocking is suggested to applied as starting point to ensure the receiver of UL sub-band is not blocked due to DL sub-band transmission
  + Option 2: AGC may be applied to adjust the receiver gain to avoid ADC saturation while impact on sensitivity. However, it seems infeasible to model this in SLS.
  + Option 3: Further study is needed on the impact, sufficient margins are need to be accommodated for environmental conditions, process and manufacturing tolerances, implementation considerations, interference environment and practical deployments.
  + Option 4: TBA
* Proposal on dependency on Gnb antenna and beam related (Question 1-5)
  + Option 1: Gnb antenna architecture has impact on RSI mode as to achieve high spatial isolation, separate antenna panels between TX and RX chain is requested.
  + Option 2: TX/RX beam pair can further contribute on RSI pending on implementation.
  + Option 3: Yes, the RSI will have dependency at least on the listed factors, but further details will need to be studied in RAN4.
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | • Proposal on granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5):  Per PRB basis is preferred to facilitate RAN1’s SLS simulation and help for further scheme design.  RSI can be modeled as frequency flat provided that certain guard band is reserved. About the size of guard band, it is implementation based. For example, for implementation without sub-band filter, guard band is less but for implementation with sub-band filter, maybe relatively larger guard band is required. Such guard band size is also critical for RAN1. If so, although normally we don’t differentiate implement in the spec, we are afraid we may need to differentiate guard band for different implementation.  • Proposal on RSI dependency on Blocking and AGC（Question 1-4）  Option 1 is OK for us.  We guess the purpose of question 1-4 is to ensure RSI will not block LNA or ADC. If so, we just need to make sure RSI at LNA input port will not block LNA and don’t need to reflect AGC operation details to RAN1. RSI at LNA input port should be taken care. And option 1 is one option to evaluate such RSI at LNA input.  • Proposal on dependency on Gnb antenna and beam related (Question 1-5)  In our tdoc 2212312, we suggest to differentiate RSI requirements for different BS class. And choose some typical factors to reflect the dependency on Gnb antenna and beam related for each BS class. |
| Ericsson | Regarding the values proposed in the table:  For spatial isolation, it needs to be clarified whether the quoted isolation is element-element, sub-array-sub-array, panel-sub-array or panel-panel. Also of interest is the bandwidth over which the isolation is achieved; some techniques (e.g. RF chokes) achieve isolation over a relatively narrow bandwidth, whereas others achieve isolation over a wider bandwidth. For a cost-effective implementation, the bandwidth over which TX suppression can be achieved needs to be wide enough that the SBFD carrier can be configured anywhere within the band. Apart from that, our investigations suggest that the isolation depends on the beam steering direction at TX and RX. In general, for isolation over a reasonable bandwidth, by combining techniques for achieving isolation our EM simulations suggest an isolation of around 70Db is achievable for a beam in boresight over a reasonable bandwidth. With beam steering, this isolation may increase or decrease by 10Db. RAN4 should consider further the impact of beam steering.  For frequency isolation, assuming 45Db ACLR is a reasonable starting point. Actually, many contributions assume a 45Db difference in PSD between the DL and UL parts. The RAN4 ACLR requirement is actually based on defined carrier bandwidths, not PSD. As an approximation, assuming 45Db PSD difference is probably Ok though. On the other hand, improving TX emissions suppression could be a less complex alternative than relying only on digital cancellation techniques, in particular for cross-sector interference and so we think that assuming current BS performance is OK for a baseline, but considering improvements in TX performance over the current performance should not be ruled out.  For beam nulling, our observation so far is that the degrees of freedom to create the far field beam are compromised, and so it is not so obvious that the beam nulling improvement does not come at the expense of degrading coverage elsewhere. Also, if beam nulling is intended to suppress intra-array interference, then nulling in the near field needs to be simulated with EM simulations. Before deciding values, it should be clarified how/whether the nulling works in the near field and the impact to the far field patterns.  For digital IC, the IC needs to cancel all transmitter impairments, including non-linear effects such as clipping etc.. It needs to take into account all TX-RX paths within the array. Also, it may well need to be capable of cancelling RX impairments. Furthermore, for a complexity, size, weight and energy efficient BS, the BS transmitter and receiver will need to operate on multiple carriers, which cause a more complex signal to cancel. To assess the feasibility and possibility of digital IC, more detail is needed on the detailed signal structure to be cancelled before values can be concluded.  In the tables of suppression values, there are currently no RX impairments. Our observation is that for receivers meeting current requirements, the receivers would be blocked. Even if not blocked, for WA BS, the receivers would need a significantly improved IIP3 performance (in ther order of 0dBm) than receivers meeting current requirements. For MR BS, the receiver impairment may be less significant for receivers meeting current requirements but should be investigated further.  Regarding granularity, in our view interference suppression values can be quoted as frequency flat and to the sub-band level if used in RAN1 system simulations. It is not obvious why a finer granularity would be needed. For considering digital IC, a more detailed model of the signal structure is needed. (Option 1)  Regarding AGC, although AGC can suppress blocking, it depends on the architecture. If the AGC is before the LNA then the AGC will increase the noise figure of the receiver, hence suppressing the blocking will degrade the NF and reduce the coverage gains. If the AGC is closer to the ADC then it will have much less impact on the noise figure, but it will not prevent e.g. saturation of the LNA by the blocker. Hence more elaboration of the assumed architecture and position of the AGC is needed to assess whether there is still degradation due to e.g. LNA saturation, or whether the AGC causes a noise figure increase. More study is needed.  The RX degradation and performance can be studied assuming a receiver that meets current requirements, but if the receiver is blocked or creates too larged degradations then the feasibility of improvements to the receiver needs to be considered.  Regarding the relationship between antenna and beams, our observation is that the beam steering directions have an impact on the achieved isolation. This should be considered further when replying on an isolation value (option 2, 3) |
| China Telecom | * Proposal from company according to factors requested by RAN1 for FR1: for Wide Area BS, 140-185 can be provided as an initial range to RAN1, which can be further refined by RAN4. * Proposal on granularity on frequency domain and question on frequency flat model possibility: Option 2 is supported. * Proposal on dependency on Gnb antenna and beam related (Question 1-5): Agree with Option 1 and 2. |
| Samsung | Pending on discussion in issue 2-1-1 for Criteria on gNB UL receiver sensitivity degradation due to self-interference, 1dB de-sensitivity is assumed here tentatively. At least results shown in R4-2211562, R4-2212493, R4-2212486, R4-2213690 and R4-2212117 demonstrate the feasibility to provide the enough RSI level to ensure the UL 1dB de-sensitivity level due to SBFD self-inference. To facilitate RAN1 study in SLS this one can be delivered in initial reply at least as starting point. For detail range for each factors asked by RAN1 ideally we aim to provide the level at least for some factors based on common understanding. For remaining ones the summary tables (with related source tdoc#) in thread summary can be attached for information since the details can be further checked in each contribution. Obviously there may also be other aspects can be added in LS if agreeable and feasible to be applied in RAN1 SLS.   * On granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5): we support a frequency flat model which can be scaling down to subband or RB level, even though it is not convinced yet on the necessity to scaling to RB level. And the guard band may or may not be needed pending on implementation. * on RSI dependency on Blocking and AGC（Question 1-4） as suggested in our contribution the option 1 is applied as one checking point on wehtehr the receiver to be blocked or not which can be implemented in RAN1 SLS if the RSI level for each factor can agreed and provided. And the option 2 is also our understanding that this factor may not be needed in SLS. For option 3, further study would not be precluded but it should also not block the preliminary reply to RAN1 with to facilitate their evaluation. * on dependency on Gnb antenna and beam related (Question 1-5) : our input is based on option 1. And option 2 has already covered in measurement antenna isolation in our contribution. And option 3 can be mentioned in reply LS as reality that further study always allowed. |
| Huawei | • Proposal on granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5):  Option 3, frequency flat model can be assumed with some guard band is assumed. RAN4 can provide an overall RSI to RAN1 at early phase.  • Proposal on RSI dependency on Blocking and AGC（Question 1-4）  Option 1 could be applied as starting point.  • Proposal on dependency on gNB antenna and beam related (Question 1-5)  All options looks agreeable. |
| Intel | * Proposal on RSI dependency on Blocking and AGC（Question 1-4） * The first priority is ensure Option 1, so that the LNA is not saturated. Option 2 could also be considered to avoid saturating the ADC, but this may be too complicated for SLS model   Proposal on dependency on Gnb antenna and beam related (Question 1-5)   * Option 1: has largest impact, yet factors in Option 2 , 3 need to be also studied |
| ZTE | For the proposals for question 1-2,  from our understanding, it’s better to reply to RAN1 with two sets of values, one is from transmitter leakage into receiver and anther one is receiver selectivity. These two set of values might be different depending on the its implementation. In addition, its targeted purpose is also slight different. From receiver side, LNA/blocking/dynamic range requirement should be also considered.    For the proposals for question 1-1/3/5,  Options are not contracting with each other, RSI could be flat with some guard band reserved, in addition, it’s quite timing consuming to reach on consensus on PRB levels, since there is too many bandwidth and SCS combinations.  For the proposal for question 1-4:  All the options could be further studied in RAN4. For initial stage, we think that option 1 could be considered at least.  For the proposal for question 1-5:  We are fine with all options listed. |
| vivo | * Proposal on granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5):   From our perspective, guard band is only one of the techniques for self-interference cancellation. It is not the only way to achieve frequency flat model for RSI. For Option 3 and Option 4, if other techniques like spatial isolation, digital IC can achieve enough antennation for SI, guard band may not be needed.   * Proposal on RSI dependency on Blocking and AGC（Question 1-4）   For Option 1, in-band blocking requirement can be used as starting points. Whether to adapt the existing sensitivity degradation level to evaluate the RSI level can be further discussed.  For Option 2, we agree that AGC is hard to model in the SLS. |
| CATT | Generally, as we proposed in our contribution R4-2211709, The reply to RAN1 can be step-by-step, the first step can be a preliminary model for calibration purpose. The model and value can be updated later when there’re agreements in RAN4. So the reply in the first step can be a simple model methodology according the existing models in RAN4. The value can be in some range.  Proposal on granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5):  Option 3 can be the used in the 1st step reply.  Proposal on RSI dependency on Blocking and AGC（Question 1-4）  Our understanding is that this issue can be studied in RAN4 internally. The conclusion for this issue would be two directions: Feasible or x dB REFSENS degradation. So any detail information for this is not useful for RAN1.  Proposal on dependency on Gnb antenna and beam related (Question 1-5)  Again, we don’t think we need to provide many details to RAN1 and may aspects are not isolated as which are understood currently in RAN1.   * So for the study, our suggestion is that separating FR1 and FR2 may help. |
| Nokia, Nokia Shanghai Bell | For proposal on granularity on frequency domain and question on frequency flat model possibility, we agree with Option 4.  On RSI dependency on Blocking and AGC, we agree with Option 4. We think the selected value of RSI should at least guarantee that the receiver operates in linear region, and we can further discuss in RAN4 whether/how to model that for the purposes of simulations.  On dependency on gNB antenna and beam related option 3 is our view. While separate antenna panels will be needed to achieve required isolation, it is still unclear if the isolation is feasible in a practical site solution taking into account the required spacing as well as other environmental factors as e.g. reflections from clutter. Also beam pair will have impact, but further study is needed. |
| Qualcomm | Given the complexity of near-field modeling of the antenna radiation patterns (intra-array), RAN4 should provide value ranges for the spatial isolation capability without delving into how to model the spatial coupling between the antenna elements/ components. In this regard, spatial isolation should be defined as panel to panel to provide an accurate measure of the gNB isolation capability in the antenna domain.    As explained in detail in our contributions, gNB antenna configuration should be based on two panels configuration with split of the antenna elements for simultaneous downlink transmission and uplink reception. In our RAN1 paper [R1-2205031], our measurement results show at least 80-90 dB spatial isolation can be achieved between the two Tx and Rx panels with the antenna array center-to-center distance is 65 cm at 28 GHz.  Question 1-1/3/5  Support option 4. We have observed that with few RBs (i.e., 5PRBs) offset from the edge DL RB, the leakage power is almost flat across the RBs. These few RBs are utilized as guard band to protect the UL signal from higher self-interference in case not rejected by some receiver filtering.    Question 1-4  it would be safe for a study to assume no in-channel selectivity at the legacy UE’s receiver – any power in the received channel influences the AGC, which in turn leads to desensitization when there is significant interfering power. Thus, AGC will be necessary to be applied. More discussions within RAN4 are needed to agree if this can be modelled in SLS.  Question 1-5  Support option 1. The spatial isolation and beam nulling capabilities will depend on the gNB antenna and beam characteristics. |
| Kumu Networks | Proposal on isolation table should consider improvement from RF cancellation and Beam Nulling jointly. For the table, we proposed the beam nulling line items should include isolation from any type of analog cancellation including RF cancellation.  FR 1:  Spatial isolations : 70 dB  Frequency isolations : 45 dB  Beam Nulling + RF cancellation : 30 dB-40 dB  FR 2:  Spatial isolations : 80-90 dB  Frequency isolations : 28 dB  Beam Nulling + RF cancellation : 30 dB-40 dB  Base on our simulation and hardware measurements, the combine effect can give up to 30 dB cancellation. This will also preserve antenna gain from beamforming. With RF cancellation, LNA saturation can be avoided. |

#### Issue 2-1-3: co-channel inter-subband gNB-gNB CLI modelling

* Proposal on feasibility and how to model co-site gNB-gNB CLI modelling
  + Option 1: For co-site gNB-gNB CLI modelling, the RSI range level proposed for self-interference cancellation shall be mandatory supported
  + Option 2: the same as inter-site gNB-gNB CLI modelling
  + Option 3: similar modelling as for self-interference but using new parameter expressing the overall isolation between Rx and Rx between co-located sectors. Assumption is same time-frequency operation between sectors. Digital interference suppression is not feasible.
* Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity
  + Option 1: UE IBE requirement based model on TX and ICS requirement based model on RX
  + Option 2: gNB ACLR based model on TX and ICS requirements based model on RX
  + Option 3: gNB ACLR based model on TX and In-band blocking requirements based model on RX
  + Option 4: (1/2-step) flat ACLR based model for TX and flat ACS based model with possible consideration on antenna isolation and subband filter pending on implementation
  + Option 5: Models are valid only if receiver RF front-end operates in linear region.
  + Option 6: Same Transmitter leakage and receiver impairment model as used for investigating gNB self-interference, but antenna isolation is replaced with inter-site isolation.
* Recommended WF
  + TBA

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| **Company** | **Comments** |
| CMCC | • Proposal on feasibility and how to model co-site gNB-gNB CLI modelling  Option 3 is preferred.  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  Option 4 is preferred. Flat ACLR instead of IBE. Flat ACS instead of ICS. |
| Ericsson | For co-site inter-gNB CLI modelling, the transmitter and receiver radio impairment models can be the same as for self-interference. An appropriate model is needed for inter-sector isolation. Our EM simulations indicate that around 45-55dB suppression is feasible (depending on vertical separation of TX-RX). Digital cancellation between sectors is likely to be complex and challenging. (Option 3)  For inter-site gNB CLI modelling within the same operator, the same TX and RX radio impairment models can be applied. The antenna isolation should be replaced by a model of the inter-site isolation (option 6) |
| China Telecom | * Proposal on feasibility and how to model co-site gNB-gNB CLI modelling: Option1 or Option 2. For Co-site co-channel inter-subband gNB-gNB CLI, digital IC is available for intra-operator, but unavailable for inter-operator cases. |
| Samsung | * Co-site gNB-gNB CLI modelling: we support option 1 as for the co-channel co-site gNB it should be deployed by a single operator or at least collaborating operators which makes the option 1 valid. * Inter-site gNB-gNB CLI modelling: we propose as option 1.Since this is co-channel case, not sure ACLR and ACS would be always achievable pending on implementation for inter-site case. But this is common preference we are open to consider this a starting point. We also agree that the PL should be considered in this case pending on inter-node distance. |
| Huawei | • Proposal on feasibility and how to model co-site gNB-gNB CLI modelling  Similar modelling but there could be different parameters  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  Option 6, the difference is path loss isolation. |
| Intel | Proposal on feasibility and how to model co-site gNB-gNB CLI modelling  Option 3: Similar model but replacing isolation and possibly also considering nearby reflections which could be of similar magnitude  Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  Option 6 |
| ZTE | • Proposal on feasibility and how to model co-site gNB-gNB CLI modelling  For co-site co-channel inter-sub-band gNB-gNB, the assumption is slightly different from self interference case especially from antenna isolation part assumptions. This is different from gNB-gNB CLI where SIC might be not possible. For option 3, we don’t think that digitial IC is impossible, it’s still possible.  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering  This is different from co-site case where digital interference cancellation; for other part, the antenna isolation,pathloss is also different. |
| vivo | * Proposal on feasibility and how to model co-site gNB-gNB CLI modelling   Option 3 is preferred.  In our view, co-site gNB-gNB CLI can not be seen as equal as Self interference within gNB. Some SIC techniques used within gNB may not be suitable for gNB-gNB CLI. We think Option 1 is not reasonable.  For Option 2, path loss between inter-site gNB-gNB needs to be considered, and it is not entirely the same with co-site gNB-gNB scenario.   * Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity   For the Tx side, ACLR can be a starting point for gNB. However, we may need further discuss whether it can be used for subband directly.  For Rx side, gNB has in-channel metric ICS and we think it can still be used for subband level. |
| CATT | **Proposal on feasibility and how to model co-site gNB-gNB CLI modelling**  Our understanding is that SIC technology for gNB self-interference may not be used for co-site scenario because the Tx signal from aggressor gNB is not known by the victim gNB. Other aspects may be ok to follow the single gNB parameters.  **Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity**  From RF perpective, it’s similar with the co-existence simulation. So the co-existence simulation parameters can be a starting point. For the SB performance, some assumptions should be decided, like BS SB configuration, GB, out of SB emission performance, etc. |
| Nokia, Nokia Shanghai Bell | On co-site gNB-gNB CLI modelling, we agree with Option 3.  On inter-site gNB-gNB CLI modelling, we support Option 5 and Option 6. |
| Qualcomm | Co-site gNB-gNB CLI modeling: Support option 1 where self-interference mitigation capability should be assumed for CLI mitigation in order to ensure successful reception of the UL signals at the victim gNB.    For inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity, support option 2. RAN4 to discuss how to model inter-site isolation, rough link budget analysis can be conducted to determine the amount of desense depending on system level parameters. |

#### Issue 2-1-4: co-channel inter-subband UE-UE CLI model

* Proposal on feasibility and how to model UE-UE CLI modelling considering unwanted emission and receiver selectivity
  + Option 1: UE IBE requirement based model on TX and gNB ICS requirement based model on RX
  + Option 2: UE ACLR based model on TX and UE ACS requirements based model on RX pending on sub-band configuration
  + Option 3: UE IBE requirement based model and estimation on RX model for UE with no ICS capability as figure from R4-2212562.(R4-2212160/R4-2212493 also assume 0 ICS from UE RX side)

SNR (dB)

REFSENS + 45 dB

REFSENS + 35 dB

REFSENS

44

DL power in all RBs (dBm)

34

SNR Regime for high DL power

Figure 3.2-1: DL SNR in a receiver of a UE without in-channel selectivity

-1

* + Option 4: UE IBE requirement based model and UE ACS requirement based model on RX
  + Option 5: UE IBE requirement based model and UE maximum input level as threshold on RX
    - If inter-subband interference is higher than the threshold, it is assumed it will result large receiver degradation and hence the RX will not correctly decode the data
    - For inter-subband interference that is smaller than the threshold, treat the blocker as interference, i.e. consider a dB-to-dB increase of interference due to blocker power
* Recommended WF
  + TBA

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| Company | Comments |
| MediaTek | Will respond further later, but please note that in **R4-2212160** we also modelled Inter-subcarrier interference due to non-orthogonality between Tx and Rx. Interestingly (see figures 2a-2d) it shows a higher level of interference for 1st adjacent RB compared to IBE emissions when there is large timing offset, with lesser impact of large frequency error. **We suggest (as in Proposal 2 in that document) that inter-sub-carrier leakage (ICI) is taken into account too for the zero ICS case.** |
| CMCC | For Tx, IBE requirement is applicable because we need to make sure legacy UE could also work in SBFD network. for Rx, if no Rx selectivity is assumed, we are afraid UE-UE interference may be severe. Some other method is required to make sure UE-UE coexistence. For example, some scheme design in RAN1? |
| Xiaomi | For Tx, we support using UE IBE requirement based model as it is in channel case. For Rx, if ICS based mode is considered, since current requirement is under the condition that the wanted and interfering signal are placed adjacently around Fc , we may need to further study whether the requirement could be also applied for all other RB allocation case. |
| Ericsson | For the UE-UE inter-sub-band model, in our view considering ACLR and SEM is sufficient, but using IBE as a baseline instead can also work. For the receiver, ACS is needed. |
| Samsung | We fully support that at least for legacy UE should be supported in transparent way for SBFD operation. Hence existing UE RF requirement should be referred in the discussion.  As explained in our contribution the UE ACLR in TX and UE ACS in RX can be applied if that’s “adjacent channel” from UE perspective and co-channel from BS perspective. This is pending on sub-band configuration as pointed in option2.  If that is also co-channel case from UE perspective, the UE IBE should be applied for TX side And for RX side the proposal in option 3 and option 5 can be taken into account as starting point, which do not preclude potential further discussion on other factors. |
| Apple | We support Option 5 as we proposed it. On TX side, Ericsson pointed out whether the IBE requirement or ACLR/SEM requirement should be used depends on how the UL subband used by the UE in a channel is viewed as some RBs within a channel or as an independent channel. Our view is it should be viewed as RBs within a channel, unless the UE is explicitly configured to operate with a channel that either covers or corresponds to the subband. |
| Huawei | For TX, ACLR or IBE can apply depends on the filter assumption. And for RX, it also depends on the filter assumption of the UE receiver, two options can be considered, one is UE ACS and the other is 0 dB which means no filtering on the inter-subband. |
| ZTE | For co-channel UE to UE, it should follow the in-band emission from transmitter and for receiver side, there might be no ACS requirement, or receiver selectivity if reusing the current UE RF desgin |
| vivo | Issue 2-1-4: co-channel inter-subband UE-UE CLI model First of all, we agreed with Samsung that existing UE RF requirments shall be referred in the discussion to ensure the legacy UE can be supported in SBFD operation.  For the Tx side, we agree that IBE should be used.  However, for the Rx side, UE does not have in-channel selectivity requirement in exsiting specifications. We are open to discuss ACS and maximum input level with further discussions. For Option 2 and Option 4, ACS is defined for channel bandwidth, however, whether it can be used for subband configuration needs further clarification. For Option 5, if we refer to the UE spec, the maximum input level is also defined for channel bandwidth. We are not sure whether it can be applied to subband level. |
| CATT | If UE is the legacy UE, then current requirements may be a reasonable assumption, such as IBE, etc. And UE has Rx AGC, so seems option 5 is a good starting point. |
| Nokia, Nokia Shanghai Bell | Related to UE IBE and UE ACS. We support Option 4 based on requirements.  Related to UE maximum input level and thresholds We support first sub-bullet of Option 5 but the second sub-bullet needs further clarifications: For example, what is the power level where interference component start to appear and secondly whether dB-to-dB relationship is correct if the cause of interference is non-linearity and/or we are at power levels where AGC starts to work? |
| Qualcomm | Support option 3. Co- channel inter-UE CLI depends on two UE-resident aspects: 1) the transmitting UE’s unwanted emissions in the non-allocated RBs in the same channel BW, and 2) a receiving UE’s in-channel selectivity if present. Aspect 1 can be conveniently upper-bounded by the emissions mask in the IBE requirement, found in clause 6.4.2 of TS38.101-x. For aspect 2, it would be safe for a study to assume no in-channel selectivity at the legacy UE’s receiver – any power in the received channel influences the AGC, which in turn leads to desensitization when there is significant interfering power. A state-of-the-art receiver’s effective noise figure as a function of power in the channel with DL RBs can be approximated as shown in figure 3.2-1. Note that here, ‘power’ refers to the cumulative power present inside the channel BW, agnostic of interferer or wanted signal. Receiver de-sense can be estimated based on knowledge of the power in the wanted RBs and the power in the interfering RBs. |
| MediaTek | For Tx side, the existing IBE requirement is appropriate as a per-RB measure.  For Rx side, we should assume no ICS (meaning no filtering assumed to block the signal as it would in adjacent channel).  However, regarding the Rx modelling:   * Maximum input level requirement and broader UL-DL power imbalance impact to AGC is relevant, but Option 3 is not altogether clear to us and would need further discussion. * Inter-subcarrier interference due to non-orthogonality between interfering signal and receiving wanted signal is relevant as highlighted in our initial comments above (and as modelled in our paper), so should be considered too. |

#### Issue 2-1-5: adjacent-channel gNB-gNB CLI model

* Proposal on feasibility and how to model co-site gNB-gNB adjacent channel CLI modelling
  + Option 1: For co-site gNB-gNB CLI modelling, the RSI range level proposed for self-interference cancellation shall be assumed.
    - Option 1a: As for option 1, but in case TX or RX improvements above the minimum performance to meet 3GPP requirements is considered for gNB self-interference mitigation, for adjacent channel the other operator gNB performance shall be assumed to be the minimum to meet 3GPP, not improved.
  + Option 2: the same as inter-site gNB-gNB CLI modelling
  + Option 3: TBA
* Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity
  + Option 1: gNB ACLR based model on TX and gNB ACS requirements based model on RX
    - Option 1-1: Apply the same ACIR model as Rel-16 CLI modelling
    - Option 1-2: Antenna gain would be different for wanted signal and unwanted signal. Hence separate calculation from ACLR and ACS perspective is more accurate.
  + Option 2: TBA
* Recommended WF
  + TBA

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| Company | Comments |
| CMCC | • Proposal on feasibility and how to model co-site gNB-gNB adjacent channel CLI modelling  For co-site gNB-gNB CLI modeling, similar modelling as for self-interference but using new parameter expressing the overall isolation. Digital interference cancellation is not feasible.  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  Option 1-2 seems more reasonable although normally we use the same antenna gain for wanted and unwanted signal. |
| Ericsson | For adjacent channel gNB-gNB modelling, option 1a; for gNB of another operator, ACLR and ACS performance based on 3GPP specifications should be assumed. |
| China Telecom | • Proposal on feasibility and how to model co-site gNB-gNB adjacent channel CLI modelling: Similar to co-site co-channel inter-subband gNB-gNB CLI. Digital IC depends on whether it belongs to the same operator.  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity: Agree with Option 1-2. |
| Samsung | Co-site gNB-gNB adjacent channel CLI modelling: we support option 1(not including the part in 1a) as proponent. At least for FR2 no colocation scenario between gNBs considered currently in specification. Hence from this angle the co-cite gNB-gNB even on adjacent channel should be considered as intra-node case at least for FR2.  Inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity : option 1-1 is what applied in legacy adjacent channel study and we support it as baseline. If there is strong request to consider option 1-2, we can provide tentative reply as: gNB ACLR based model on TX and gNB ACS requirements based model on RX shall be applied, it’s allowed but not mandatory to take complex but more accurate model the antenna gain difference between wanted signal and interfering signal. |
| Huawei | • Proposal on feasibility and how to model co-site gNB-gNB adjacent channel CLI modelling  Option 2, ACLR and ACS can apply.  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  We support Option 1-2 |
| ZTE | • Proposal on feasibility and how to model co-site gNB-gNB adjacent channel CLI modelling  ACLR and ACS should be applied here since different carrier could be coming from different operators and it’s impossible to have digital interference mitigations..  Some sub-band filtering could also help further increase ACLR/ACS performance if implemented  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  Use ACLR anc ACS and some sub-band filtering could also help further increase ACLR/ACS performance if implemented |
| CATT | • Proposal on feasibility and how to model co-site gNB-gNB adjacent channel CLI modelling  ACLR/ACS is a starting point, some of gNB SIC technologies can’t be used if aggressor Tx signal information is used. If SBFD BS performance is the same with legacy ACLR/ACS performance or if the ACLR/ACS should assume SB BW or the carrier BW should be discussed and decided.  • Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity  This is based on the single gNB RF performance. The same issue with the above, BW should be decided for the RF performance. |
| Nokia, Nokia Shanghai Bell | For co-site gNB-gNB CLI, we support option 1a. We can not assume that legacy base stations perform better than current spec.  For inter-site gNB-gNB CLI, we support option 1-1 with the same reasoning. |
| Qualcomm | For co-site gNB-gNB adjacent channel CLI modelling: Support option 1. Option 1a is not clear. In case there is Tx or Rx improvements, the CLI capability will be covered within the assumed RSI value ranges.  For inter-site gNB-gNB CLI modelling: Support option 1-1. Option 1-2 can be considered in an advanced stage and it requires more work towards accurate modeling of the wanted and unwanted signal. In typical RAN4 coexistence studies, the ACLR is considered beamformed as the in-band signal. |

#### Issue 2-1-6: adjacent-channel UE-UE CLI model

* Proposal on feasibility and how to model UE-UE CLI modelling considering unwanted emission and receiver selectivity
  + Option 1: UE ACLR based model on TX and UE ACS based model on RX which is the same ACIR model as Rel-16 CLI study
  + Option 2: UE ACLR model with 2step size(FR1 example: ACLR1/2=28/33dB) on TX and UE ACS based model on RX if blocker is smaller than maximum input level of UE
  + Option 3: Use UE SEM as starting point for per-RB/sub-band measures at max power. At lower powers, an indicative mask could be FFS.
* Recommended WF
  + TBA

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| Company | Comments |
| CMCC | option 1 is not feasible. In 38.838, one UE occupies all RB configuration. But for SBFD, UE may only be configured with part of carrier, ACLR1/2 or even larger order ACLR is required when UE in SBFD network interfere UE in legacy TDD network as shown below    when UE in legacy network interfere UE in SBFD network, we should model ACLR as shown in following fig to find out actual received interference in SBFD DL subband. Frequency flat is suggested. |
| Xiaomi | We may need to decide which granularity (e.g., per channel, subband or per RB) should be considered first. |
| Ericsson | For the adjacent channel UE-UE CLI model, we are OK to use ACS and ACLR. We should take care not to make assumptions on the frequency profile of the ACLR that are not supported by the UE requirements in the end. |
| Samsung | Option 1 can be taken as starting point to reply RAN1 LS as widely applied in legacy study on adjacent channel UE-UE CLI study. Further study on fine model is not precluded. |
| Apple | Option 2 is proposed to ensure the adjacent channel emission is not over-estimated. However, we are OK to use the current UE ACLR model and assume the emission level in the adjacent channel is flat. UE SEM in Option 3 is not a good option as it is independent of the UE TX power. We are open to further discussion.  On receiver selectivity/blocking, we also propose to consider a 5dB SNR degradation due to receiver gain backoff in addition to ACS, as shown in R4-2211880. |
| Huawei | Option 2 is ok to us. |
| ZTE | We are fine with option 1 and maybe fine with option 2 also , however more discussion on option 2 is still needed. |
| vivo | For Option 1, the simulation assumption in Rel-16 CLI study does not consider SBFD operation, thus, the same ACIR model may not be directly used for adjacent channel UE-UE CLI model. For Option 3, we prefer not to use UE SEM, since it is not a metric for conventional adjacent channel co-existence. We think ACLR and ACS can be used as a starting point with further scaling considering subband configuration. |
| CATT | We’re ok with option 2. |
| Nokia, Nokia Shanghai Bell | We prefer to model the adjacent UE-UE CLI using existing ACLR (flat response in frequency) and ACS models .Therefore we support Option 1. |
| Qualcomm | Support option 1 as a starting point. |
| MediaTek | Support Option 3.  ACLR and ACS do not tell us anything about the actual level of interference in a particular victim RB/sub-band as they are just average measures. Or do we tell RAN1 that it is not feasible to define per RB/sub-band in adjacent channels? |

### Sub-topic 2-2: Adjacent channel co-existence study

*The sub-topic is target to summary and collect view on adjacent channel co-existence study regarding three aspects on:*

* *Necessity on SLS simulation in RAN4(Issue 2-2-1)*
* *Scenario for adjacent channel co-existence study in RAN4(Issue 2-2-2~2-2-6)*
* *Detail assumptions based on CLI and legacy study(remaining issues)*

#### Issue 2-2-1: Necessity on SLS in RAN4

* Proposals
  + Option 1: The RAN4 shall conduct co-ex study as the study results will be the discussion basis for RAN4 to:

- Determine the supporting co-ex scenarios for SBFD operation;

- Check the adjacent channel interference with existing ACIR (ACLR/ACS) requirements in SBFD operation;

- Check the feasibility of new ACIR (ACLR/ACS) requirements for new SBFD-capable gNBs.

* + Option 2: Discuss the differences on deployment scenario and/or parameter between SBFD operation and Rel-16 CLI to decide whether additional SLS needed or not.( R4-2211710/R4-2212847)
  + Option 3: Adjacent channel SLS can be covered in RAN1(R4-2212161)
* Recommended WF
  + TBA

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| Company | Comments |
| Samsung  (Runsen, T) | We support Option 1. Option 1 is the only option that we believe RAN4 can fulfill its task. The supporting scenarios, checking existing requirements or discussing new requirements on SBFD-capable gNBs are mandate of RAN4 group by this item.  For Option 2, we would like to point out that the previous CLI study was only focusing on the half-duplex transmission scenarios. Even in 50% mismatch scenario it studied, there’re only 50% number of BSs and UEs are transmitting as aggressor. It’s different to the typical SBFD scenario, where it has all BSs and UEs transmitting at the same time. Thus, the SBFD should be studied. While, we support the idea from Option 2 that the scenarios and/or parameters can be referring to the CLI study as much as possible. And of course, we need to discuss and determine some new SBFD parameters and/or scenarios in RAN4 for the new study.  For Option 3, our understanding is that the RAN1 SLS and RAN4 SLS have totally different purposes. Moreover, the simulation modeling and methodologies are not the same in two WGs. From previous experiences, like NTN (quite recently), we often find the results from two WGs are not very comparable as they are designed differently to provide different perspectives of the fact. |
| CMCC | Based on whether new requirement is needed or not. According to R16 CLI, legacy requirement is not applicable for some scenario. therefore, if we want to make sure co-existence for such scenario, we need such new SLS to derive new ACLR rather than just identifying whether current requirement is applicable or not as in R16 CLI. Even if RAN1 simulate adjacent channel case, ACLR/ACS requirements are based on RAN4 input and RAN1 doesn’t simulate aiming at defining new RF requirement. If we reuse legacy ACLR/ACS, SBFD deployment is limited. E.g. interference occurs when macro SBFD co-exist with legacy TDD network.  Therefore, option 1 is preferred. Besides, to reduce work load, we can only focus on the scenario where system performance degradation is observed in R16 CLI study. |
| Ericsson | Regarding co-existence studies, it is important to take into account that the work is currently a SI examining feasibility of duplexing schemes and not a WI developing requirements, and also the existing work on CLI co-existence.  The WID tasks RAN1 with studying performance, including assuming co-existence in adjacent channels and RAN4 with studying the feasibility of RF requirements.   * Study the performance of the identified schemes as well as the impact on legacy operation assuming their co-existence in co-channel and adjacent channels (RAN1). * Study the feasibility of and impact on RF requirements considering adjacent-channel co-existence with the legacy operation (RAN4).   Co-existence studies for SBFD may aim to answer the following issues:   1. Whether SBFD UEs can cause inter-UE and inter-operator CLI towards a victim operator. 2. If SBFD sub-frames are configured in DL sub-frames of the static TDD, whether the SBFD performance is impacted by gNB-gNB interference from other operators 3. In case SBFD sub-frames are configured in UL sub-frames of the static TDD whether the adjancent operators are degraded by gNB-gNB interference form the SBFD operator.   For (1), UE-UE CLI was studied in Rel-16. A difference for SBFD is the fact that the UL transmission of the SBFD operator is separated from the DL reception of the victim operator by the DL sub-band. This depends completely on the model used for UE interference. If the model is based on ACLR/ACS then there is no difference to the existing studies and no need for co-existence simulations. A second question is whether monte-carlo system simulation is always the right way to model UE-UE co-existence, since the random placing of UEs will mean that the probability of UEs being close is small, which may lead to UE-UE interference being statistically averaged out. It may be acceptable that UE-UE CLI does exist, but is mitigated by a low probability of UEs being next to one another, but it could be discussed further.  The first step seems to be for RAN4 to discuss and agree on the UE interference model though, not to start co-existence simulations.  For (2) above, degradation caused to the SBFD by other operators is clearly related to the gain of SBFD. Since the aim is not to define requirements and the co-existence is part of gain assessment, our view is that (2) would be best performed in RAN1 in order that the assumptions are fully aligned with RAN1 and an overall view is taken on the gain and impacts. If the impact to the SBFD operator is assessed in RAN4 instead, then an effort needs to be made to align to the RAN1 gain assessment and inform RAN1 that they should take the results into account when considering overall gain (if there is an impact). There is no need to study requirements on adjacent operator BS. RAN4 could study whether improvements are needed to SBFD to deal with adjacent operator interference. Clearly the task needs to be aligned between RAN1 and RAN4 and the same set of assumptions applied; in our view the best first step would be for RAN1 to assess whether adjacent channel interference from other operators makes a significant difference to the performance gain using their agreed scenarios and then, if it does to request RNA4 to study whether the RX performance can or needs to be improved.  Regarding (3), it is not obvious why UL slots would be used for SBFD if the aim is to increase UL coverage. If they are used though then the scenario for gNB-gNB interference is basically the same as Rel-16 and it is not obvious why new co-existence simulations would be needed in either RAN4 or RAN1 as opposed to re-using the Rel-16 conclusions for this scenario.  In summary:   * UE-UE CLI: Firstly discuss interference model; quite possibly no simulations needed * Adjacent operator gNB – SBFD operator gNB: Firstly RAN1 can check if the gains are impacted and if needed RAN1 can request RAN4 to check if it is feasible and useful to improve RX requirements.   SBFD operator – adjacent operator gNB-gNB: The Rel-16 conclusions can be applied. |
| Apple | Option 2 can be used as a baseline for further consideration. Meanwhile, we need to compare the ACLR/ACS model used in R16 CLI and the one to be used in SBFD.  We are also OK with Option 3, since RAN1 is conducting SLS by incorporating the CLI modeling RAN4 provides to them in their simulations. We would also like to emphasize that any discussion on UE RF requirement impact needs to take place in RAN4. |
| Huawei | In general, we think SLS in RAN4 is needed, since the e.g., target scenario, interference type are different from Rel-16 RAN4 CLI study, while we share the understanding that RAN4 workload should be carefully treated. On the other hand, even though RAN1 might conduct simulations for co-existence, we think it is not conflict with RAN4 because the RAN1 purpose and evaluation method are different. |
| Intel | Option 2 allows further discussion to evaluate if RAN4 needs additional SLS beyond RAN1. Option 3 is also possible using simplified adjacent channel parametric model. |
| ZTE | In general, we are fine with option 1 and option 2, anyway we think that coexistence study in RAN4 for SBFD is needed to define the RF requirements. RAN4 and RAN1’s focus is different and we cannot leave the work to RAN1 totally. |
| vivo | We are ok to use Option 1 as a starting point. Since RAN1 is also conduction SLS, we think it is for RAN1 and RAN4 to determine the supporting co-ex scenarios for SBFD operation; For the ACIR requirements, RAN4 can be in charge. |
| CATT | Option 2 is a good starting point. |
| Nokia, Nokia Shanghai Bell | We support Option 1 and Option 2. On Option 3, we think that SLS effort in RAN4 (if any, depending on prior feasibility analysis) should focus on co-existence aspects while RAN1’s SLS scope can instead focus on identifying and quantifying potential enhancements for SBFD. |
| Qualcomm | Support options 1 and 2. RAN4 will have to check the simulation assumptions, scenarios, KPIs, and outcome in Rel-16 CLI prior to developing new SLS. |
| MediaTek | From some comments above, it seems that:  - At least one company believes we are defining some new UE requirements in this study item. That seems more like a WI activity.  - One company believes that doing the same thing independently in 2 different WGs leads to more robust outcome. Not sure that concept scales so well.  We would appreciate it if Samsung could explain the completely different purposes of the 2 simulations. From what I see from the proposed assumptions below, it looks alarmingly similar to what I see submitted in RAN1 contributions.  We would then support a **modified** Option 2 below:  *Option 2bis: Discuss the differences on deployment scenario and/or parameter between SBFD operation and Rel-16 CLI,* ***and also the differences in terms of the objectives/motivations of any SLS campaign in RAN4 compared to SLS being performed in RAN1,*** *to decide whether additional SLS needed or not.*  NOTE: Although we provide SLS below, we think more discussion on the motivation is needed. |

#### Issue 2-2-2: FR1 SBFD scenarios for co-ex study

* Proposals
  + Option 1: UMa and InH as baseline scenarios for SBFD operation.
  + Option 2: UMi as optional deployment scenario.
  + Option 3: UMa as high priority, Indoor as low priority.
* Recommended WF
  + Agree on Urban Macro as FR1 baseline scenario, further discuss the rest scenarios.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen, T) | We agree with the WF, to at least agree on Urban Macro as a baseline to progress.  For the rest scenarios, we support Option 3 as starting point, we believe the SBFD co-ex will not be an issue on SBFD -> TDD DL case. While we don’t think it is necessary, if the time and resources allowed, we are open to study Indoor case. |
| CMCC | Recommended WF is OK for us.  we suggest to only focus on the scenario where system performance degradation is observed in R16 CLI study.  So macro->macro is baseline; besides, indoor->indoor is also suggested because R16 CLI shows performance degradation if BS has higher power compared to UE for indoor to indoor case. |
| Ericsson | We provide some comments on simulations scenarios and assumptions, however we think that before getting into simulations, the questions on the need and responsibilities for simulations should be solved.  Scenario depends on the envisaged use cases and deployment scenarios for SBFD. All envisaged deployment scenarios should be considered, and worst cases simulated. At least Uma, but also Umi may be a relevant deployment scenario and should be considered |
| Apple | Should RAN4 seek to align with RAN1 on the deployment scenarios first? |
| Huawei | Agree with focusing on Macro scenario first. |
| Intel | Agree with WF. UMa as baseline to make progress. Later in SI could consider Indoor as secondary priority. |
| ZTE | It’s better to have the alignment with RAN1 simulation evaluation. However we are fine with Urban macro as high priority, for other use case, it should not be precluded. |
| CATT | Ok with the WF. |
| Nokia, Nokia Shanghai Bell | We support the WF from the moderator. |
| Qualcomm | Support option 1. UMa scenarios with relatively high EIRP will result in extreme inter-gNB CLI, while indoor scenarios will lead to extreme inter-UE CLI due to the close proximity. |

#### Issue 2-2-3: FR2-1 SBFD scenarios for co-ex study

* Proposals
  + Option 1: UMa and InH as baseline scenarios for SBFD operation. UMi and IAB as optional.
  + Option 2: Urban macro (UMa), Indoor and Urban micro (UMi) as baseline.
  + Option 3: Urban macro (UMa) as baseline. Indoor as low priority.
  + Option 4: Urban macro (UMa) as starting point.
* Recommended WF
  + Agree on Urban Macro as FR2 baseline scenario, further discuss the rest scenarios.

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| --- | --- |
| Company | Comments |
| Samsung  (Runsen, T) | We agree with the WF, to at least agree on Urban Macro as a baseline to progress.  For other scenarios, considering CLI results and our preliminary results, we support Option 3 as a starting point. We believe it doesn’t mean other scenarios are precluded in future meetings with new findings and proposals. |
| CMCC | Recommended WF is OK for us.  we suggest to only focus on the scenario where system performance degradation is observed in R16 CLI study. |
| Ericsson | Same as FR1; certainly Uma and probably Umi should be considered. |
| Apple | Same comment as for the FR1 case. |
| Huawei | Agree with focusing on Urban Macro scenario first. |
| Intel | Agree with WF |
| ZTE | Similar as comments as FR1 |
| CATT | OK with the WF. |
| Nokia, Nokia Shanghai Bell | We support the WF from the moderator (assuming 200 meter ISD is also agreed as discussed in issue 2-2-7) |
| Qualcomm | Support the WF. In general, we are ok with options 1 and 2. RAN4 will has to consider multiple scenarios to fully assess the feasibility of SBFD deployments. |
| MediaTek | Uma and InH as priority. |

#### Issue 2-2-4: Frequencies for co-ex study

* Proposals
  + Option 1: FR1: 4GHz as exemplary frequency, FR2: 30GHz as exemplary frequency.
  + Option 2: FR1: 3.5GHz as exemplary frequency; FR2: 30GHz as exemplary frequency.
  + Option 3: FR2-2 as optional.
* Recommended WF
  + Further discuss the above options

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen, T) | We prefer Option 1, 4GHz for FR1 and 30GHz for FR2 as exemplary frequency in co-ex study.  We do not think FR2-2 should be considered in the co-ex SLS evaluation. |
| CMCC | Option 1 aligned with RAN1 agreement and R16 CLI assumption.  FR2-2 should not be considered. |
| Huawei | Option 1. FR2-2 should be precluded. |
| Intel | Option 2, although Option 1 is a close second choice. |
| ZTE | Fine with option 1 which is also aligned with RAN1 |
| CATT | Ok with option 1. |
| Nokia, Nokia Shanghai Bell | We prefer Option 2 in order to be aligned with RAN1. |
| Qualcomm | Ok with option 1. |

#### Issue 2-2-5: Aggressor and victim combinations with aggressor baseline for co-ex study

* Proposals

**NR TDD DL as victim**

* + Option 1-1: Aggressor baseline: NR TDD DL in adjacent channel; Aggressor: SBFD in adjacent channel.
  + Option 1-2: TBA

**NR TDD UL as victim**

* + Option 2-1: Aggressor baseline: NR TDD UL in adjacent channel; Aggressor: SBFD in adjacent channel.
  + Option 2-2: Do not consider NR TDD UL as victim in SBFD co-ex study.

**SBFD as victim**

* + Option 3-1: Aggressor baseline: SBFD in adjacent channel; Aggressor: NR TDD UL.
  + Option 3-2: Aggressor baseline: SBFD in adjacent channel; Aggressor: NR TDD DL.
  + Option 3-3: Aggressor baseline: SBFD intra-system; Aggressor: NR TDD DL.
* Recommended WF
  + Further discuss the above options in different cases.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | In general, we support Option 1-1 as the baseline scenario.  For other two scenarios, we believe it requires further discussions:  For NR TDD UL as victim, we do not think this is inside the scope of this item, thus we support Option 2-2.  The SID clearly defined the SBFD study is targeted to expand the UL, which means the scenario is focused on having new SBFD operation in TDD DL time slot to increase UL capacity. In that sense, there’s no such cases that SBFD would co-ex with TDD UL transmission. So that we don’t think RAN4 should study the co-ex case with legacy TDD UL.  For ‘SBFD as victim’, we support our Option 3-3. With the above understanding, we do NOT support Option 3-1. For the Option 3-2, the difference is only evaluation baseline, in this first meeting, we are open to this option as well. |
| CMCC | SBFD operation in legacy UL slot is as 2nd priority. So such case is also suggested as 2nd priority during simulation. |
| Ericsson | For NR TDD as victim, option 1-1 is OK, but before doing simulations RAN4 should discuss the UE interference and RX model. Quite probably the existing CLI results can be referred to. Also it could be discussed whether a worst-case analysis should be considered as well as monte-carlo simulation (since the simulation has a low probability of UEs scheduled near to each other)  For NT TDD UL as victim, this is only relevant if SBFD is performed in UL slots. In any case, the Rel-16 CLI conclusions on BS-BS interference are relevant for that case.  For SBFD as victim, this is part of the gain assessment for SBFD; the impact on SBFD in a multi-operator environment should be studied with NR TDD interference to SBFD. Option 3-2 seems to be the relevant adjacent channel case, but it is not clear to us what is meant with option 3-3. |
| Huawei | OK to evaluate SBFD between legacy TDD DL slot as the start. |
| Intel | Same as Ericssson’s description for these cases. |
| ZTE | It’s better to list the coexistence scenarios in the table instead of by wording as above |
| Nokia | The baseline performance to compare against should be normal synchronized NR TDD as both the victim and the aggressor.  The second step should be SBFD as one system, and legacy TDD as the other system. This yields the impact of SBFD to TDD, and of TDD to SBFD.  The third step should be two SBFD systems. |
| Qualcomm | Agree with ZTE.  NR TDD DL as a victim: Support option 1-1.  NR TDD UL as victim: This implies that SBFD is operating in UL, which is out of scope for the current SI. Thus we support option 2-2.  SBFD as victim: We are ok with option options 3-1 and 3-3. |
| Qualcomm | Ok with option 1. |
| MediaTek | Option 1-1. Understood that TDD UL as victim was lower priority as agreed by RAN#96. |

#### Issue 2-2-6: SBFD sub-band configurations in co-ex study

* Proposals
  + Option 1: Proposed to consider both SBFD Subband configuration#1 with {DUD} pattern, which means one SBFD slot consists of one UL subband at the center of the channel bandwidth and two DL subbands at two sides of the channel bandwidth, and SBFD Subband configuration#2 with {DU} pattern, which means one SBFD slot consists of one UL subband at one side of the channel bandwidth and one DL subband at the other side of the channel bandwidth, in RAN4 co-ex study. These two configurations are shown in figure below:

(a) (b)

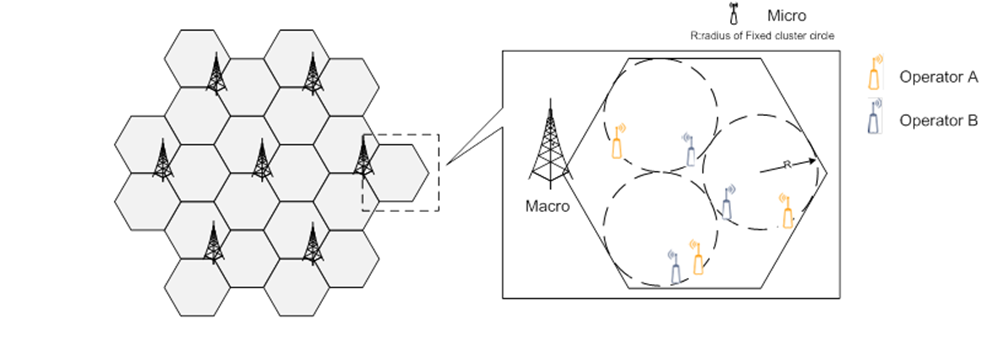
Fig.2 SBFD subband configurations: (a) #1 {DUD}, (b) #2 {DU}

* + Option 2: RAN4 decides SBFD configuration in the adjacent channel co-existence study.
* Recommended WF
  + Agree on Option 1.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We believe both options should be considered in RAN4 co-ex study. It means we support Option 1.  From our understanding, the DUD configuration obviously has less adjacent channel interference if the ACLR steps are considered for UE. The DU would be the worst case if the adjacent channel is placed close to the UL subband. And just for information, our preliminary results in R4-2212697 were based on ‘DU’ configuration, and it gives positive results. |
| CMCC | Option 1 is preferred. |
| Ericsson | Before concluding on a or b, we need to study and conclude on the BS and UE interference models towards the adjacent channel and hence what difference a or b makes. |
| Apple | Are both (a) and (b) on equal footing in RAN1’s consideration? If so, both should be considered. However, RAN4 can start with one first. |
| Intel | RAN1 seems to prefer Option 1: DUD. We can evaluate both, but DUD will likely be needed for RAN1. |
| ZTE | From our understanding, Figure a and Figure b should be both considered. From coexistence perspective, option b might be worst case |
| CATT | If adjacent channel is considered, option b? |
| Nokia, Nokia Shanghai Bell | If the applied models are frequency flat, then both configurations should end up with the same outcome and it is unnecessary to simulate both. One is enough and it could be either.  In case models are not flat in frequency, then both configurations need to be simulated. |
| Qualcomm | Support option 1. As a starting point, RAN4 can prioritize the DUD configuration. |

#### Issue 2-2-7: Inter-site distance (ISD)

* Proposals
  + Option 1: FR1 UMa with 500m ISD, FR2 UMa with 200m, Indoor Hotspot with 20m (Same as TR 38.828)
  + Option 2-1: FR2 UMi with 100m ISD
  + Option 2-2: FR2: 3 clusters randomly dropped in Macro cell on edges, with ISD not specified (TR 38.828)



* Recommended WF
  + Agree on Option 1 and try to converge Option 2-1 and 2-2.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support recommended WF.  It seems Option 1 is for FR1 Uma, FR2 Uma and Indoor, and they are same as TR 38.828. No issue for that.  Option 2-1 provides FR2 UMi with 100m ISD, which seems a supplementary information to TR 38.828 as described in Option 2-2. Our understanding is that the TR 38.828 and 38.803 only asked to randomly drop Micro clusters on Macro cell edges, and with specific ranges of BS-UE distance inside those micro clusters. The ISD of these clusters were not given.  Thus, we are open to the values provided in Option 2-1. And if it’s agreed by most experts in RAN4, we are OK to agree on Option 1 and Option 2-1. |
| CMCC | Recommended WF is OK for us. |
| Huawei | Option 1, but since we might agree on choosing Macro scenario as the baseline, suggest to remove the indoor part for now.  Option 1: FR1 UMa with 500m ISD, FR2 UMa with 200m (Same as TR 38.828) |
| ZTE | Fine with option 1 and further discus other use case. For the indoor scenario, the factory case, it’s also typical to use the SBFD |
| Nokia, Nokia Shanghai Bell | Support at least Option 1. Remaining options can be discussed depending on what is agreed under issue 2-2-3 |
| Qualcomm | Ok with option 1. RAN4 should discuss the need for UMi deployments. An option to start with UMa and later consider UMi or UMa with lower ISD pending on the feasibility outcome of baseline UMa case. |

#### Issue 2-2-8: Path-loss model

* Proposals
  + Option 1: Use the path-loss models specified in TR 38.828 as baseline. [Moderator notes: as highlighted in tables below.]

Table 5.2.1.1.1-1: Single operator layout for urban macro in FR1 (4 GHz)

|  |  |
| --- | --- |
| Layout | Single layer with 19 hexagonal cell with wrap around |
| Inter-BS distance | 500 m |
| Carrier frequency | 4 GHz |
| Path-loss model | - Macro(Aggressor) → Macro(Victim)  - Macro-to-UE: UMa see TR 38.803 [5]  - Macro-to-Macro: UMa (h\_UE = 25 m) see TR 38.803 [5]  - UE-to-UE: Outdoor UE – Outdoor UE see TR 36.828 [6]  + penetration loss see TR 38.803 [5] |
| BS Tx power | 49 dBm |
| UE Tx power | 23 dBm |
| BS antenna configurations | (Mg,Ng,M,N,P)=(1,1,8,8,2) (dH,dV)=(0.5,0.8)λ  Note 1,2 |
| BS antenna height | 25 m |
| BS antenna element gain + connector loss | 5 dBi (assuming antenna 1.8dB loss) |
| BS receiver noise figure | 5 dB |
| UE antenna configuration | Omni |
| UE antenna height | hUT=3(nfl-1)+1.5  nfl for outdoor UEs: 1  nfl for indoor UEs: nfl~uniform(1,Nfl) where Nfl = 1 |
| UE antenna gain | 0 dBi |
| UE receiver noise figure | 9 dB |
| Multi operators layout | uncoordinated operation (100% Grid Shift) |
| Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations.  Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match. | |

Table 5.2.1.1.2-1: Single operator layout for Indoor scenarios in FR1 (4 GHz)

|  |  |
| --- | --- |
| Layouts | 1. Indoor-to-Indoor : 6 BSs per 120 m x 50 m  cid:image001.png@01D3E3E6.8A8631F0  2. Indoor-to-Macro : the number of Indoor per macro cell (drop randomly) = 1 |
| Inter-BS distance | Indoor-to-Indoor: 20 m |
| The minimum distance between Macro to Indoor: [35] m |
| Minimum BS-UE (2D) distance | Indoor-to-Indoor: 0 m |
| Minimum UE-UE (2D) distance | Indoor-to-Indoor: 1 m ~ 3 m |
| Carrier frequency | 4G Hz |
| BS TX power | 24 dBm |
| UE TX power | 23 dBm |
| Path-loss model | - Indoor (Aggressor) → Macro (Victim):  - BS-to-BS: InH-office + penetration loss see TR 38.803 [5]  - BS-to-UE: InH-office + penetration loss see TR 38.803 [5]  - UE-to-UE: Outdoor UE – Outdoor UE   + penetration loss see TR 38.803 [5], TR 36.828 [6]  - Indoor (Aggressor) → Indoor (Victim)  - BS-to-BS: InH-office see TR 38.803 [5]  - BS-to-UE: InH-office see TR 38.803 [5]  - UE-to-UE: InH-office see TR 38.803 [5] |
| BS antenna | FR1 BS antenna element pattern for Indoor scenario from subclause 5.2.1.5.1 / ceiling |
| BS antenna height: | 3 m |
| UE antenna | Omni |
| UE antenna height | 1.5 m |
| Antenna gain of UE | 0 dBi |
| Cell selection criteria | Cell selection is based on RSRP |
| BS receiver noise figure | 5 dB |
| UE receiver noise figure | 9 dB |
| UE power control | Power control as defined in Section 5.2.3.4 |
| Multi operators layout | uncoordinated operation (100% Grid Shift) |

5.2.2.1.1 Urban macro

Table 5.2.2.1.1-1: Single operator layout for urban macro in FR2 (30 GHz)

|  |  |
| --- | --- |
| Network layout | hexagonal grid, 19 macro sites, 3 sectors per site with wrap around |
| Inter-site distance | 200 m |
| BS antenna height | 25 m |
| Path-loss model | - Macro (Aggressor) – Macro (Victim)  - Macro-to-Macro: UMa (h\_UE = 25 m) see TR 38.803 [5]  - Macro-to-UE(V): Uma + penetration loss see TR 38.803 [5]  - UE-to-UE: UMi (h\_BS=1.5 m ~ 22.5 m)   + penetration loss see TR 38.803 [5] |
| Shadowing correlation | Between cells: 1.0  Between sites: 0.5 |
| Multi operators layout | uncoordinated operation (100% Grid Shift) |

5.2.2.1.2 Dense urban

Table 5.2.2.1.2-1: Single operator layout for Dense urban in FR2 (30 GHz)

|  |  |  |
| --- | --- | --- |
| Parameters | Values | Remark |
| Network layout | Fixed cluster circle within a macro cell. | note1 |
| Number of micro BSs per macro cell | 3 | 3 cluster circles are in a macro cell. 1 cluster circle has 1 micro BS. |
| Radius of UE dropping within a micro cell | < 28.9 m |  |
| BS antenna height | 10 m |  |
| Channel model | Micro (A) – Micro (V) see TR 38.803 [5]  - Micro-to-Micro: UMi   (h\_UE=10 m)  - Micro-to-Micro UE:   UMi + penetration loss  - Micro (UE)-to-Micro (UE):  UMi (h\_BS=1.5 m ~ 22.5 m)   + penetration loss between UEs |  |
| Shadowing correlation | Between cite: 0.5 |  |
| Multi operator layout | Cluster circle is coordinated | Note 2 |
| Minimum distance between micro BSs in different operator | 10 m |  |
| Note 1: Micro BS is randomly dropped on an edge of the cluster circle. All UEs communicate with micro BS, i.e. macro cell is only used for determining position of micro BS. As a layout of macro cell, hexagonal grid, 19 macro sites, 3 sectors per site model with wrap around with ISD = 200 m is assumed.  Note 2: Macro cell is collocated. Micro BS itself is randomly dropped. | | |

5.2.2.1.3 Indoor

Table 5.2.2.1.3-1: Single operator layout for Indoor scenarios in FR2 (30 GHz)

|  |  |  |
| --- | --- | --- |
| Parameters | Values | Remark |
| Network layout | Indoor-to-Indoor : Total 12 BSs  (operator A: 6 BSs & operator B: 6 BSs) 120 m x 50 m  cid:image002.png@01D4D8DE.1325CA10  Indoor-to-macro: Indoors are placed at different locations |  |
| Inter-site distance | Indoor – Indoor = 20 m |  |
| The minimum distance between Macro to Indoor: [35] m |  |
| BS antenna height | 3 m | ceiling |
| Path-loss model | Indoor(Aggressor) → Indoor(Victim)  - BS-to-BS: InH-office see TR 38.803 [5]  - BS-to-UE: InH-office see TR 38.803 [5]  - UE-to-UE: InH-office see TR 38.803 [5]  Indoor (Agressor) → Macro (Victim)  - BS-to-BS: InH-office (h\_UE = 3 m) + penetration loss see TR 38.803 [5]  - BS-to-UE: InH-office (h\_UE = 3 m) + penetration loss see TR 38.803 [5]  - UE-to-UE: InH-office (h\_BS = 1.5 m) + penetration loss see TR 38.803 [5] |  |
| Shadowing correlation | N/A |  |
| Multi operators layout for indoor | Uncoordinated operation (100%) |  |

* + Option 2: Inter-gNB coupling loss can be evaluated utilizing existing gNB-UE channel models in TR 38.802/38.901 with the proper adjustments on deployment and antenna parameters to mimic a gNB-gNB scenario. (Channel model: TR 38.901, Inter-UE: TR 38.901, Inter-gNB: 38.901)
* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1.  For the pathloss model for CLI links, the BS-BS, UE-UE links, we tends to re-use the models used in TR 38.828. |
| CMCC | Option 1 is OK for us. |
| Ericsson | Regarding the channel model, there is some discussion in RAN1 that the proportion of LoS for BS-BS may be more than assumed in the TR. For UE-UE we propose to use 38.901 rather than 36.828. The channel model assumption should be aligned with RAN1 view.  To reduce simulation time, it may be sufficient to consider 7 sites rather than 19 |
| Huawei | Option 1 is OK. |
| ZTE | We are fine with option 1 to reuse the existing TR 38.828. |
| Nokia, Nokia Shanghai Bell | At least for gNB-gNB links and gNB-UE links we prefer Option 2 (TR 38.901) in order to be aligned with RAN1 decision. For UE-UE links, we prefer the UE-UE channel model used for flexible duplex evaluation in TR 38.802. |
| Qualcomm | We proposed option 2, but we are also ok with option 1 if majority of companies agreed on it. |

#### Issue 2-2-9: Grid shift considerations:

* Proposals
  + Option 1: The 100% grid shift shall be applied for evaluation, while 0% grid shift doesn’t need to be considered
  + TBA
* Recommended WF
  + Agree on Option 1.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1. |
| CMCC | We support option 1. 0% grid shift will blocking receiver. |
| Ericsson | 0% grid shift should be evaluated by means of examining intra-site BS isolation in more detail; simulation could be after the isolation is established. 10% grid shift should be included in order to check whether BS-BS effects are deployment dependent.  Option 2: 100%, 10%, 0% after intra-site isolation is established |
| Huawei | We support Option 1, but we are open to other non-zero grid shift if needed. |
| ZTE | 100% shift, however for the reply LS to RAN1, we also need to reply co-site case, it might be a bit confusing at the end |
| Nokia, Nokia Shanghai Bell | RAN4 must consider other grid shifts than 100%, in order for any new study to make sense. Co-site/co-location using at least 0% shift is required for practical deployments. |
| Qualcomm | We support option 1. For 0% grid shift, this will boil to the intra-BS case, which will be dominated by the high interference power levels and will not be meaningful. |
| MediaTek | 0% and 100% at least for Uma. |

#### Issue 2-2-10: UE distribution in macro scenario:

* Proposals
  + Option 1: Re-use assumptions in TR 38.828. [Moderator note: as highlighted in table below]

Table 5.2.1.3-1: UE distribution for FR1

|  |  |
| --- | --- |
| Scenarios | UE distribution |
| **Indoor-to-Indoor** | Indoor -> Indoor = 1 user per Transmission Reception Point; 100% indoor |
| **Macro-to-Indoor** | Indoor <-> macro = 1 user per Transmission Reception Point; Indoor has 100% indoor UE. Macro victim has 50% indoor UE and 50% outdoor.  Indoor <-> macro = Aggressor: 1 user per Transmission Reception Point, 100% indoor. Victim: 1 user per Transmission Reception Point, 100% outdoor |
| **Urban Macro**  **(Macro-to-Macro)** | 20% indoor and 80% outdoor |

5.2.2.3.1 Urban Macro (Macro-to-Macro)

**Table 5.2.2.3.1-1: UE distribution for Urban Macro case in FR2**

|  |  |  |
| --- | --- | --- |
| **UE location** | **Outdoor/indoor** | Outdoor and indoor |
| **Indoor UE ratio** | 0% |
| **LOS/NLOS** | LOS and NLOS |
| **UE antenna height** | 1.5 m ≦ hUT ≦ 22.5 m |
| **UE distribution (horizontal)** | | Uniform |
| **Minimum BS - UE distance (2D)** | | 35 m |

5.2.2.3.2 Dense Urban (Micro-to-Micro)

**Table 5.2.2.3.2-1: UE distribution for Dense Urban case in FR2**

|  |  |  |
| --- | --- | --- |
| **UE location** | **Outdoor/indoor** | Outdoor and indoor |
| **Indoor UE ratio** | 80 % |
| **50% low loss, 50% high loss** | Low/high Penetration loss ratio |
| **LOS/NLOS** | LOS and NLOS |
| **UE antenna height** | Same as 3D-UMi in TR 36.873 [8] |
| **UE distribution (horizontal)** | | Uniform |
| **Minimum BS - UE distance (2D)** | | 3m |

5.2.2.3.3 Indoor-to-Indoor and Indoor-to-Macro

**Table 5.2.2.3.3-1: UE distribution for Indoor cases in FR2**

|  |  |
| --- | --- |
| **Scenarios** | **UE distribution** |
| Indoor-to-Indoor | Indoor -> Indoor = 1 user per Transmission Reception Point; 100% indoor |
| Macro-to-Indoor | Indoor <-> macro = Aggressor: 1 user per Transmission Reception Point, 100% indoor. Victim: 1 user per Transmission Reception Point, 100% outdoor |

* + Option 2: 80% outdoor, 20% indoor for UMa and Indoor hotspot.
  + Option 3-1: Random and uniform UE dropping. 20% outdoor in cars: 30km/h and 80% indoor in houses: 3km/h.
  + Option 3-2: Adopt following steps for UE dropping:
  + Step 1: Randomly drop a cluster within a macro cell geographical area considering the minimum distance between macro TRP to cluster centre, e.g., 100m , where the size of each cluster is 120 x 50 (m);
  + Step 2: 80% UEs are randomly and uniformly dropped within the cluster, and 20% UEs are randomly and uniformly dropped outside the cluster.
* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1 for outdoor/indoor ratio of FR1 and FR2 scenarios which is same as TR 38.828. (Option 2 seems a similar option)  For Option 3-1, we don’t think the user moving speed is considered in previous RAN4 co-ex study. And for its proposed 80% indoor ratio for both FR1 and FR2, we are open to discussion.  For the cluster-dropping methodology proposed in Option 3-2, it was also not considered in previous RAN4 co-ex studies, we would like to hear more rationale of having this new method.  How about we start with traditional random UE dropping methods as starting point/baseline first and see more results and comparison from the proponent about this ‘new UE dropping method’? |
| CMCC | For option 1, user number s per transmission reception point should equal to the number of sub-bands. For example, if use DUD, then 3 users per transmission reception point. If use DU configuration, 2 users per TRP. Except for user numbers, other parameter is OK for us.  For option 2 and option 3-1, we don’t need to consider user velocity and just static simulation is enough.  For option 3-2, its much like two layer deployment, the first step is much like indoor deployment method with 20% user and step 2 is the outdoor deployment. But option 3-2 doesn’t differentiate outdoor and indoor. If we only consider 1-layer deployment, it’s better to randomly and uniformly drop users. |
| Ericsson | Since the target gain for SBFD is coverage expansion, we think that the percentage of indoor UEs should be much higher for FR1, as these are the ones that are coverage challenged and SBFD deployments would presumably address situations with coverage issues. UEs should be clustered to ensure that UE-UE effects are captured reasonably. Again RAN4 should align with RAN1 eventual outcome. |
| Apple | UE distribution model is important as it determines the likelihood of two UEs being very close to each other, which would represent the worse-case for UE-to-UE interference. In RAN1 SLS, they need to agree on the model too. Do we plan to reuse their model? |
| Huawei | As the proponent of Option 3-2, our intention is trying to find a better solution to observe the impact from UE-UE CLI, since RAN1 may have similar discussion for this purpose. For now we can accept to apply random UE distribution as the start. |
| ZTE | We support to have the option 1 |
| Nokia, Nokia Shanghai Bell | For FR1 UMa, we support 80% indoor UE proportion with uniform UE dropping as the baseline. An alternative UE placement model where e.g. 80% of the UEs are placed in one or more clusters may also be additionally considered.  In our view, there is a need to schedule more than 1 UE per TRP at least for FR1. Otherwise UE-UE interference challenges will not be observed. |
| Qualcomm | Ok with option 1. SBFD deployment studies should focus on scenarios with high percentile of UEs being indoor to force the UEs to send with maximum Tx power (due to high penetration loss), thus, creating extreme interference scenarios and analyzing the system's feasibility under such cases. Thus, we propose to adopt 20% outdoor and 80% indoor for UMa. |
| MediaTek | We support using some level of clustering between UEs. We provide a proposal in R1-2206983, so would expect some alignment with RAN1 decisions. |

#### Issue 2-2-11: Noise figures:

* Proposals
  + Option 1: Re-use TR 38.828 assumptions -- FR1 BS: 5dB, UE: 9dB; FR2 BS: BS: 10dB, UE: 10dB.
  + Option 2: BS 7dB, UE 13dB for FR1 and FR2.
* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1.  We are not sure if it’s appropriate to assume same NF for both FR1 and FR2 as in Option 2. |
| CMCC | Option 1 is OK for macro BS. But for indoor, 13dB for FR1 BS. |
| Ericsson | Option 1 should be used to ensure comparable baseline sensitivity as existing BS/UE. |
| Apple | Option 1 is OK, especially if we want to use the R16 CLI analysis as a baseline. |
| Huawei | OK with Option 1. |
| Intel | Option 1: Re-use TR 38.828 assumptions |
| ZTE | Okay with option 1 |
| Nokia, Nokia Shanghai Bell | Option 1 |
| Qualcomm | Ok with option 1. |

#### Issue 2-2-12: BS antenna and TRP considerations

* Proposals
  + Option 1: Re-use TR 38.828 for legacy TDD BS, and consider two options for SBFD BS antenna and TRP power:
  + Option 1-1: Utilize half of its original panel for SBFD UL and DL each. In this case, the TRP and elements number for DL and UL in SBFD BS will be half of the TDD BS configuration.
  + Option 1-2: Utilize an extra panel for subband UL operation. In this case, the TRP and element number for DL and UL in SBFD BS will be the same as TDD BS configuration.

|  |  |  |
| --- | --- | --- |
|  | FR1 Macro Urban | FR2 Macro Urban |
| BS antenna configurations | For Legacy TDD:  (Mg,Ng,M,N,P)=(1,1,8,8,2) (dH,dV)=(0.5,0.8)λ  For SBFD:  Option 1: (Mg,Ng,M,N,P)=(1,1,4,8,2) (dH,dV)=(0.5,0.8)λ  Option 2: (Mg,Ng,M,N,P)=(1,1,8,8,2) (dH,dV)=(0.5,0.8)λ | For 30 GHz legacy TDD: (1, 1, 8, 16, 2)  For SBFD:  Option 1 (1, 1, 8, 8, 2)  Option 2 (1, 1, 8, 16, 2) |
| BS Tx power | For Legacy TDD:  49 dBm  For SBFD:  Option 1: 46 dBm  Option 2: 49 dBm | For legacy TDD:  43dBm  For SBFD:  Option 1: 40 dBm  Option 2: 43 dBm |

* + Option 2: RAN4 to further discuss the antenna pattern and related power for FR1 BS and FR2 BS due to the separate Tx and Rx antenna array assumption.
  + Option 3: Adopt [49 dBm] for FR1 and [38 dBm] for FR2 BS Tx power assumption.
  + Option 4: Parameters proposed for the specific scenarios in table below.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | **Deployment scenarios** | | |
| **UMa deployment** | | **Indoor Hotspot (Indoor office C in TR 38.808)** |
| BS antenna pattern | | (M, N, P)=(8, 16, 2), with upper half panel for DL TX, bottom half for UL RX | |
| BS Tx power | | FR1: 45dBm,  FR2: BS: 40 dBm/80 MHz. EIRP should not exceed 73 dBm  Note: For system BW larger than above, Tx power scales up accordingly. | FR1: BS: 31 dBm  FR2: 23 dBm per 80 MHz. EIRP should not exceed 58 dBm  Note: For system BW larger than above, Tx power scales up accordingly. |

* + Option 5: Use extended AAS model defined in TR 38.803, Table 5.2.3.2.4-2 as the sub-array is essential to be able to provide TX/RX isolation required for SBFD. For FR1 parameters in TR 38.803, Table 5.2.3.2.4-3 is proposed as starting point. Parameters for FR2 is proposed as Table 4 in R4-2212620.
* Table 5.2.3.2.4-2: Extended AAS model (TR38.803)

| **Description** | **Equation** |
| --- | --- |
| Peak normalized element radiation pattern |  |
| Peak gain normalized element radiation pattern |  |
| Sub-array excitation |  |
| Sub-array radiation pattern | , where |
| Array excitation |  |
| Composite array radiation pattern | , where |

Table 5.2.3.2.4-3: Antenna array parameters( within 1710-4990MHz in TR38.803)

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Macro Rural | Macro suburban | Macro urban |
| Element gain (dBi) (Note 2) | 6.4 | 6.4 | 6.4 |
| Horizontal/vertical 3 dB beam width of single element (degree) | 90º for H 65º for V | 90º for H 65º for V | 90º for H 65º for V |
| Horizontal/vertical front‑to‑back ratio (dB) | 30 for both H/V | 30 for both H/V | 30 for both H/V |
| Antenna polarization | Linear ±45º | Linear ±45º | Linear ±45º |
| Antenna sub-array configuration (Row × Column)  (Note 4) | 4 × 8 elements | 4 × 8 elements | 4 × 8 elements |
| Horizontal/Vertical radiating sub-array spacing | 0.5 of wavelength for H, 2.1 of wavelength for V | 0.5 of wavelength for H, 2.1 of wavelength for V | 0.5 of wavelength for H, 2.1 of wavelength for V |
| Number of element rows in sub-array | 3 | 3 | 3 |
| Vertical element separation in sub-array () | 0.7 of wavelength of V | 0.7 of wavelength of V | 0.7 of wavelength of V |
| Pre-set sub-array down-tilt (degrees) | 3 | 3 | 3 |
| Array Ohmic loss (dB) (Note 2) | 2 | 2 | 2 |
| Conducted power (before Ohmic loss) per sub-array (dBm) (Note 3) | 28 | 28 | 28 |
| Base station horizontal coverage range (degrees) | +/-60 | +/-60 | +/-60 |
| Base station vertical coverage range (degrees) (Note 1) | 90-100 | 90-100 | 90-100 |
| Mechanical down-tilt (degrees) | 3 | 6 | 6 |
| Note 1: The vertical coverage range is given for the elevation angle θ, defined between 0° and 180°.  Note 2: The element gain includes the loss and is per polarization.  Note 3: The conducted power per sub-array assumes 4x8x2 sub-arrays (i.e., power per H/V polarized element).  Note 4: 4 × 8 means there are 4 vertical and 8 horizontal radiating sub-arrays.  Note 5: For the case of 3 elements per sub array, dv will be 2.1 wavelengths. | | | |

Table 2 Additional parameter sets relevant for FR2(in R4-2212620)

| **Parameter** | **24250 to 52600 MHz** | |
| --- | --- | --- |
| **Urban macro** | **Dense urban** |
| Element gain | 5.5 dBi | 5.5 dBi |
| Horizontal/vertical 3 dB beam width of single element | 90 º for H  90 º for V | 90 º for H  90 º for V |
| Horizontal/vertical front to back ratio | 30 dB for both H/V | 30 dB for both H/V |
| Antenna polarization | Linear H/V | Linear H/V |
| Antenna sub-array configuration (Row × Column) | 8 x 24 | 4 x 24 |
| Horizontal/Vertical radiating sub-array spacing | 0.5l for H, 1.2l for V | 0.5l for H, 1.2l for V |
| Number of element rows in sub-array | 2 | 2 |
| Vertical element separation in sub-array (dv,sub) | 0.6l | 0.6l |
| Pre-set sub-array down-tilt | 0 º | 0 º |
| Array Ohmic loss | 2 dB | 2 dB |
| Conducted power (before Ohmic loss) per sub-array | 13 dBm | 13 dBm |
| Base station horizontal coverage range | +/-60 º | +/-60 º |
| Base station vertical coverage range | 90-105 º | 90-105 º |
| Mechanical down-tilt | 15 º | 10 º |

* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1 together with its sub-bullets Option 1-1 and Option 1-2, to consider two options for BS power and UL/DL element numbers on the basis of TR 38.828 assumptions.  We think the sub-array model, proposed in Option 5, may have some issue for SBFD case. Because the antenna isolation may require some distance and/or components between the UL arrays and DL arrays, we are not sure if the sub-array model can be directly applied to such case.  We are open to hear more discussions, while we suggest the experts to consider to agree with at least one baseline option in this meeting. |
| Ericsson | Regrading BS parameters we need to describe the BS antenna used to get proper isolation. Isolation can be achieved by separating TX and RX antenna aperture and use vertical sub-arrays (which have been shown in previous tdocs examples in RAN1 contributions).  The isolation between TX and RX antenna array can be improved by selecting narrower element patterns. The element beam width is set by the area available for the element. Combining multiple elements into sub-arrays is a straightforward approach to achieve narrower element patterns and also increase the isolation between TX and RX. For SBFD the antenna array setup is essential to be able to early create isolation between TX and RX necessary to make total isolation large enough to make SFBD work properly.  As part of SBFD considerations, for AAS BS sub-arrays is a typical building practice for frequencies within FR1, FR2 and between and so should be default for simulations. For FR1 parameters are agreed in RAN4 between 1710 to 4990 MHz, for FR2 we provided input this meeting, also for 6 to 10 GHz we provided input this meeting.  To model sub-arrays properly, the extended antenna model in TR 38.803 is required. The parameters given for the frequency range 1710 to 4990 MHz can be used as starting point.  We prefer option 1-5 (use most recent model and parameters).  Regarding the split on the antenna, we need to check the BS power capability (the power feed to the TX antenna) used for the simulation. Splitting the antenna may require 3 dB higher power to be feed to the TX antenna. If not, we lose both TX gain and TX power, which will affect the coverage. |
| ZTE | We support the option 1-1, its detailed value could be further checked in the dtaft simulation assumption table. |
| Nokia, NSB | Our preference here is to first adopt similar agreement as in RAN1 and then, as a second step, discuss the antenna panel layouts:  **Agreement (RAN1#109e)**  For evaluation and comparison between SBFD and legacy TDD, assume the total number of TxRUs of the antenna array for SBFD is the same as the total number of TxRUs of the antenna array for legacy TDD. Regarding antenna elements, both of the two options can be used.   * Opt 1: The total number of antenna elements of the antenna array for SBFD is the same as the total number of antenna elements of the antenna array for legacy TDD. * Opt 2: The total number of antenna elements of the antenna array for SBFD is two times of the total number of antenna elements of the antenna array for legacy TDD. * Companies report which option is assumed in their simulation. |
| Qualcomm | We believe that different antenna panels for Tx and Rx is necessary to achieve the targeted spatial isolation. For option 5, it is not clear what additional information in terms of modelling we will get from the extended model. Agree with Samsung that it might lead to additional modeling complexity that would be preferred to be bypassed at this preliminary stage of the discussion. |
| Kumu Networks | There will be more flexibility in choosing Tx and Rx antenna array configuation if RF cancellation is included in the simulation model. |

#### Issue 2-2-13: UE antenna and Tx power

* Proposals
  + Option 1: Re-use TR 38.828 assumptions:
* FR1 max Tx 23dBm, min Tx -40 dBm with 0dBi omni directional antenna.
* FR2 max Tx 13.4dBm (peak eirp 22.4dBm), min Tx -40dBm, with antenna configuration in below table.
* Table 5.2.2.5.4-1: FR2 UE antenna element pattern

|  |  |
| --- | --- |
| Parameter | Values |
| Antenna element vertical radiation pattern (dB) |  |
| Antenna element horizontal radiation pattern (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 3 dBi (assuming 5dBi directivity and 2dB loss) |
| BS antenna configuration | (Mg, Ng, M, N, P) = (1, 1, 2, 2, 2)  Note 1,2 |
| (dv, dh) | (0.5λ, 0.5λ) |
| UE orientation | Random orientation in the azimuth domain: uniformly distributed between -90 and 90 degrees Note 3  Fixed elevation: 90 degrees |
| Note 1: Mg = number of antenna panels in elevation, Ng – number of antenna panels in azimuth, M = number of antenna elements/subarrays in elevation, N= number of antenna elements/subarrays in azimuth, P = number of polarizations.  Note 2: TX power is specified per polarization, a single polarization may be simulated under the assumption of polarization match.  Note3: This is done to emulate two panels: the configuration is equivalent to 2 panels with 180 shift in horizontal orientation and UE orientation uniformly distributed in the azimuth domain between -180 and 180 degrees.  Note 4: A 90 degree element beamwidth was assumed for simulations, even though the physically correct beamwidth would be 130 degrees. The difference in assumption does not substantially impact the simulation | |

* + Option 2: FR1 max Tx 23dBm; FR2 max Tx 23dBm (peak eirp 43dBm) with (M, N, P)=(1, 4, 2), 2 panels antennas and element gain as 1.5 dBi.
* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1.  The difference between two options are UE power and gain in FR2, option 2 suggests 23dBm TRP with peak eirp of 43dBm which may be too large for current UEs. The 38.828 assumption of 13.4 dBm TRP with peak eirp of 22.4 dBm may be more practical. |
| Ericsson | Regarding UE antenna parameters it is important to select parameters properly to minimize the modelling error. The proposed values in table will not provide correct gain. It seems to be a mix between BS and UE parameter values. Antenna model parameters values cannot be determined in isolation. Since parameters depend on each other they must be selected carefully to minimize the model error. For the UE some more work with the parameters is needed. |
| Apple | On FR2, Option 1 seems more reasonable. On Option 2, it is unclear why two panels are considered. |
| Huawei | Option 1 is OK. |
| ZTE | Fine with option 1 |
| Nokia, Nokia Shanghai Bell | Option 1 is more realistic for handheld UEs |
| Qualcomm | We proposed option 2 as the values provided in 38.828 for FR2 were too low. The reason behind two panels to minimize the blockage probability for a single panel case. |

#### Issue 2-2-14: BS mechanical down-tilt angles

* Proposals
  + Option 1: Propose to align the mechanical down-tilt angles assumptions for BS. And it is proposed to use 6 degrees for the Macro BS for FR1 and FR2 as provided in TR 38.803.
  + Option 2: Not specified for UMa, 90-deg (point to ground) for indoor.
  + Option 3: Mechanical tilt should be determined together with array parameters as a package per considered deployment scenario.
* Recommended WF
  + Agreed on Option 1 and 2.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support recommended WF.  The two options seems not conflict to each other. |
| CMCC | Recommended WF is OK for us. |
| Ericsson | Regarding the BS mechanical down-tilt angle we propose to use the parameter sets given for sub-arrays as starting point. The mechanical down-tilt angle needs to be selected considering all other parameters. Mechanical down-tilt cannot be selected in isolation. We prefer option 3. |
| ZTE | From our understanding, we can follow the RAN4 reply LS to ITU or other legacy simulation assumptions. |
| Nokia, Nokia Shanghai Bell | We support Option 2. We don’t think that Option 1 and Option 2 are mutually exclusive. |
| Qualcomm | Ok with options 1 and 2. |

#### Issue 2-2-15: Uplink power control model

* Proposals
  + Option 1: Propose to use the following as the general uplink power control model for SBFD co-existence study.

|  |
| --- |
| For downlink scenario, no power control scheme is applied.  For uplink scenario, TPC model specified in Section 9.1 TR 36.942 [9] is applied with following parameters.  - CLx-ile = –SNR\_target + UE\_maxpower – ThermalNoise – BS\_NoiseFigure + 10\*log10(BW)  - γ = 1  Where, SNR\_target for FR1 and FR2 are 15 dB. |

* + Option 2: TBA.
* Recommended WF
  + Agree on Option 1.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support our option 1.  These are not new proposed numbers/values from our side, we provided these only as supplementary information on the basis of TR 38.828, where these info are missed. |
| CMCC | Recommended WF is OK for us |
| ZTE | OKAY with option 1 |
| Qualcomm | Ok with the proposed WF. |

#### Issue 2-2-16: UE adjacent channel emissions considerations

* Proposals
  + Option 1: For FR1, it is proposed to adopt ACLR1 as 30 dBc and ACLR2 as 43 dBc for FR1 UE.
  + Option 2-1: We should at first model ACLR equivalent emission mask for legacy TDD carrier to help calculate received sub-band interference at adjacent SBFD carrier.
  + Option 2-2: We should define ACLR1, ACLR2 and even higher order ACLR model for SBFD network to help evaluate interference.
  + Option 3: Use UE SEM as starting point for per-RB/sub-band measures at max power. At lower powers, an indicative mask could be discussed.
* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support Option 1 and Option 2.  Maybe we can start with Option 1 as baseline, and further discuss if other reasonable values can be agreed in this or next RAN4 meetings. |
| CMCC | Option 2 is preferred.  when SBFD interfere legacy TDD, we may need other higher order ACLR based on SBFD configuration as below    When legacy TDD interfere SBFD, we could assume ACLR as frequency flat. |
| Ericsson | We should clarify that the UE assumption can be linked to the current UE requirements. There does not really seem to be a motivation to do simulations since we already have UE-UE studies in the CLI study, although a worst case could be considered |
| Apple | This should be merged with Issue 2-1-6. |
| ZTE | This depend on how SBFD pattern is used at the end, this could be further discussed once the SBFD pattern is more clear in RAN4. |
| vivo | Please see our reply for Issue 2-1-6. |
| Nokia, Nokia Shanghai Bell | ACLR of 30 dBc can be used as starting point. It is not clear how to utilize value for channels further away, as e.g. more than 100 MHz offset for FR1 does not appear relevant. |
| Qualcomm | We support option 1 as a starting point and then see if additional ACLR modeling is required. |
| MediaTek | Option 3, but why are we provided with different options than we were provided for the RAN1 LS response? What changed exactly? |

#### Issue 2-2-17: BS ACLR/ACS considerations

* Proposals
  + Option 1: Re-use TR 38.828 assumptions -- ACLR/ACS for FR1 BS: 45/46 dBc, FR2 BS: 28/23.5 dBc.
  + Option 2: TBA
* Recommended WF
  + Agree on Option 1.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support recommended WF. |
| CMCC | Option 1 is OK |
| Ericsson | Makes sense for the adjacent operator BS |
| Huawei | Option 1 could be used as a start, whether the assumptions need to be revised is depending on RAN4 parallel discussion. |
| Intel | Option 1 is fine. |
| ZTE | Okay with option 1 |
| Nokia, Nokia Shanghai Bell | We support the recommended WF. |
| Qualcomm | Ok with option 1. |

#### Issue 2-2-18: SBFD self-interference consideration in SLS

* Proposals
  + Option 1: Proposed to use {N = noise floor + 1dB} for the SBFD system to simulate the self-interference impact as a simplified method to evaluate its SINR/throughput.
  + Option 2: Apply Total Isolation = Spatial Isolation + NLIC + ACLR = 135 dB for intra-gNB CLI link, where Spatial Isolation plus NLIC = 90dB and Flat ACLR = 45dBc/20MHz.
* Recommended WF
  + Further discuss the above options.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support our option 1 as a simplified method to move forward for co-ex study.  The exact calculation, like proposed in Option 2, may be another approach in co-ex simulation, but the values of each stage are highly dependent on the actual implementation, so that we don’t think it can be a workable approach for general co-ex study in RAN4. |
| CMCC | Option 1 or option 3  Where option 3: RSI=Pout – minimum value of self-interference cancellation value range |
| Ericsson | The SBFD assumption should be aligned with the RAN1 study. RAN1 need to also take into account adjacent channel impacts to SBFD as it is related to the gain evaluation. |
| Huawei | Option 1 could be used as a start. |
| ZTE | Option 1 could be used |
| Nokia, Nokia Shanghai Bell | The realistic level of self-interference needs to be analysed first as part of the feasibility study before agreeing values, otherwise we risk producing erroneous and misleading results |
| Qualcomm | Ok with option 1 as a starting point. Nevertheless, RAN4 would need to discuss values listed in RAN4 regarding the total aggregate self-interference mitigation capabilities, which is also a required input from RAN1's LS to RAN4. |

#### Issue 2-2-19: Co-ex study steps

* Proposals
  + Option 1: Propose to adopt the following steps, modified from TR 38.828 and other general legacy RAN4 coex study report, as the simulation steps for SBFD coex study.

|  |
| --- |
| 1. Aggressor and victim network are generated.  - UEs are distributed randomly across the network.  2. UE associations: UEs are associated to base station based on coupling loss.  - Associations are made assuming a single element at both UE and BS.  3. Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-UE. This is done for both victim and aggressor networks.  4.  When legacy TDD system is victim, follow steps 4a:  4a. Throughput is computed considering ACI from another static TDD system as baseline aggressor:  - , where is the inter-cell interference and is the adjacent channel interference from the baseline aggressor.  When SBFD system is victim, follow steps 4b:  4b. Throughput is computed in the victim system without considering ACI as below:  - , where is the inter-cell interference.  5. Throughput is computed considering ACI below:  - , where is the adjacent channel interference. |

* + Option 2: TBA
* Recommended WF
  + Agree on Option 1.

|  |  |
| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support recommended WF. |
| CMCC | Recommended WF is OK for us |
| Ericsson | The throughput calculation for SBFD does not take into account self-interference. The assumption for self-interference should be aligned to RAN1 |
| Apple | Option 1 is OK. We also agree for SBFD, self interference needs to be considered. |
| ZTE | Okay with option 1 |
| Nokia, Nokia Shanghai Bell | The simulation framework is simplistic. Companies may also provide dynamic system simulation results.  For step 4 to establish adjacent channel interference baseline, it needs to be clarified that the two systems are using legacy TDD slot configurations. The ACI is resulting from legacy interference scenarios, i.e. UE ACLR + gNB ACS for the base station, and gNB ACLR + UE ACS for the UE. There should be no difference between legacy TDD and SBFD systems in the ACI baseline, unless the ACLR/ACS assumptions are changed. See also comments to issue 2-2-5.  For step 5, the performance should be reported separately for aligned TDD slots (i.e. legacy slots), and SBFD slots. |
| Qualcomm | Ok with option 1. |

#### Issue 2-2-20: Evaluation metrics

* Proposals
  + Option 1: It is proposed to follow the TR 38.828’s evaluation criteria to check the 50% and 5% throughput loss compared to the baseline scenario defined.
  + Option 2: TBA.
* Recommended WF
  + Agree on Option 1.

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| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support recommended WF. |
| CMCC | Recommended WF is OK for us. |
| Ericsson | For evaluating SBFD victim, the same metrics as used for evaluating gains as used in RAN1 need to be included (e.g., coverage improvement) in order to get a perspective how the adjacent channel interference is impacting the SBFD gains if this is not done in RAN1. |
| Apple | Option 1 is OK. |
| Huawei | Option 1 should be enough for RAN4 evaluation. |
| ZTE | Okay with option 1, |
| vivo | Option 1 is OK for us. |
| Nokia, Nokia Shanghai Bell | We support Option 1. Other metrics, such as latency, may also be reported. |
| Qualcomm | Ok with option 1. |
| MediaTek | Option 2: We first need to identify what we are trying to achieve that is different from what RAN1 is trying to achieve, and set performance metrics accordingly. This aspect needs clarification. |
| Kumu Networks | Should consider the impact of antenna gain when using beam nulling to reduce self interference |

#### Issue 2-2-21: Other assumptions

* Proposals
  + Option 1: Propose to adopt the system characteristics, deployment parameters and other assumptions from TR 38.828 as the starting point for SBFD co-ex study. But the assumptions should be updated accordingly to fulfill the SBFD co-ex purpose.
  + Option 2: TBA.
* Recommended WF
  + Agree on Option 1 as a general starting basis for those SLS assumptions that were not discussed.

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| --- | --- |
| Company | Comments |
| Samsung  (Runsen T) | We support recommended WF. |
| CMCC | Recommended WF is OK for us |
| Ericsson | Need to add that the assumptions need to be aligned to the RAN1 evaluation as needed. |
| Huawei | Support recommended WF. |
| ZTE | Fine with recommended WF |
| Nokia, Nokia Shanghai Bell | Support option 1. |
| Qualcomm | Ok with option 1. |

### Sub-topic 2-3: co-channel feasibility study

*Sub-topic description: this sub-topic focuses on the issues not covered in sub-topic 2-1 and 2-2.*

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

#### Issue 2-3-1: Candidates for simulation on co-channel self-interference

* FFS on below options
  + Option 1: Link level assessment for co-channel adjacent subband interference
  + Option 2: Discussion on alignment on PA model with realistic DPD component
  + Option 3: Discussion on crest factor processing model condition on whether power increased assumed for gNB DL subband TX
  + Option 4: Discussion on Receiver impairment/non-linearity factors can be modelled
  + Option 5: TBA
* Recommended WF
  + TBA

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | We don’t quite understand the purpose of this issue. We use option 2-4 to model received signal at Rx link after DPD and crest factor processing to help cancellate the Tx interference signal? If so, all above four options are OK for us. |
| Ericsson | These issues are discussed above. For a feasibility study, understanding what is realistic and feasible is a core part of understanding the feasibility and in that sense just as important as the co-existence study.  The options are not mutually exclusive; all of these things should be discussed. Our comments on these issues are captured above |
| Samsung | We agree the point that the LLS could be helpful to check feasibility perspective which can be recognized in the scope. And corresponding discussion should be not precluded. However, the possibility and necessity on alignment of simulation model for each modules/factors should be considered before we make such decision. For example, it would be time consuming discussion to abstract the model based on realistic implementation among companies. And if we tend to discuss enhanced solution the model in LLS would be even more difficult to be aligned. There is always freedom allowed in BS implementation solution as RF minimum requirement for BS is defined architecture agnostic way as much as possible.  In addition, there are also measurement results of PoC and estimation on component performance submitted in this meeting which is summarized in sub-topic 2-1. Related results, including corresponding results to be shared in future meeting, should be treated in feasibility study parallel with the LLS proposed above. |
| Intel | We support option 1-4 for further discussion:  Option 1: performing link level assessment for sub-band interference. We may be able to possibly simplify this result to a parametric model as has been done in the past.  Option 2: Because of the high linearity of the gNB Tx, we should agree on aspects of a DPD component to PA modeling  Option 4: LNA non-linearity is a must, ADC saturation may or may not be required. |
| ZTE | We think all the factors could be discussed in RAN4 to verify its feasibIlity of SBFD |
| CATT | Not sure how to discuss this kind of issues in RAN4. For example, DPD simulation results are very different with the real implementation measurement performance. CFR can be simulated in digital domain, but not sure if there’s any help to the SBFD study. |
| Nokia, Nokia Shanghai Bell | First we should align the feasibility of the values as that is needs to be done anyway for RAN1 LS reply. Similarly what needs to be modelled and which Tx and Rx impairments taken into account needs to be discussed also for RAN1 LS Reply.  Furthermore, for the feasibility of the co-channel operation as a whole, also co-channel CLI needs to be considered in addition to self-interference. |
| Qualcomm | RAN4 should focus on the feasibility and the appropriate models/ ways to be provided to RAN1 based on their questions in their LS. We do not see the need for link level assessment at this stage and it is still being discussed if it is required to be done at all in RAN1. Detailed modeling of PA, DPD, CFR, etc. will lead to quite complex discussions. Proposal to agree on simpler ways to account for the RF front end nonlinearities and impairments to be used in the SLS simulations. |

## 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* |
| *Issue 2-1-1: baseline in SBFD operation* | ***Tentative agreement:*** *below proposal should be agreeable according to feedback.*   * *Proposal to gNB*    + *Proposal 1: If found feasible, SBFD operation requires new/enhanced implementation for gNB capable of SBFD and cannot be software upgraded to existing BS(CMCC, Ericsson, CTC, Samsung, HW, Intel, ZTE, CATT, Nokia, QC, Kumu)*   + *Proposal 3: No impact on requirement applied to existing gNB or gNB not capable of SBFD operation.(CMCC, Ericsson, Samsung, HW, ZTE, Nokia, QC)* * *Proposal to UE*   + *Proposal 1: Estimate UE performance based on existing UE RF requirements and if needed extrapolated for system level studies(CMCC, Xiaomi, CTC, Samsung, Apple, HW, Intel, ZTE, vivo, CATT, Nokia, QC, MTK)* * *Criteria on gNB UL receiver sensitivity degradation due to self-interference:*   + *Proposal: minus 1dB degradation(CMCC, Ericsson, Samsung, HW, ZTE,CATT, QC)*   *Recommendations for 2nd round:*  *To be discussed further in reply LS and WF on RF feasibility study based on above tentative agreement* |
| *Issue 2-1-2: Self-interference modelling for Gnb capable SBFD operation* | *Status summary: according to feedback companies preference according for each aspect are summarized as below:*   * On granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5):   + Option 1: RSI can be modelled as frequency flat and scaling to subband level (Ericsson , Samsung, ZTE)   + Option 2: RSI can be modelled as almost frequency flat and scaling to RB level(CMCC, CTC)   + Option 3: Frequency flat model can be assumed with possible guard band reserved between subband pending on implementation (Samsung, HW, ZTE)   + Option 4: A frequency flat model can be used, as long as sufficient guard band is assumed between DL and UL sub-bands.(Nokia, QC) * Proposal on RSI dependency on Blocking and AGC（Question 1-4）   + Option 1: The in-band blocking is suggested to applied as starting point to ensure the receiver of UL sub-band is not blocked due to DL sub-band transmission (CMCC, Samsung, HW, Intel, ZTE)     - Besides blocking, LNA and dynamic range can be considered for receiver side(ZTE, Ericsson)   + Option 2: AGC may be applied to adjust the receiver gain to avoid ADC saturation while impact on sensitivity. However, it seems infeasible to model this in SLS. (CMCC, Samsung, Intel)   + Option 3: Further study is needed on the impact, sufficient margins are need to be accommodated for environmental conditions, process and manufacturing tolerances, implementation considerations, interference environment and practical deployments.   + Option 4: TBA(Nokia) * Proposal on dependency on Gnb antenna and beam related (Question 1-5)   + Option 1: Gnb antenna architecture has impact on RSI mode as to achieve high spatial isolation, separate antenna panels between TX and RX chain is requested.(Samsung, HW, Intel, ZTE, QC)   + Option 2: TX/RX beam pair can further contribute on RSI pending on implementation. (Ericsson, Samsung , HW, Intel, ZTE)   + Option 3: Yes, the RSI will have dependency at least on the listed factors, but further details will need to be studied in RAN4.(Ericsson, Samsung, HW, Intel, ZTE, Nokia)   ***Tentative agreement****: based on above summary on companies’ preference tentative agreement is provide as below*   * Tentative agreement on granularity on frequency domain and question on frequency flat model possibility (Question 1-1/3/5): RSI can be modelled as (almost) frequency flat at least could be scalled to subband level   + FFS on guardband assumption between subband for SBFD   + FFS on necessity/feasibility on RB level scaling * Tentative agreement on RSI dependency on Blocking and AGC（Question 1-4）   + Proposal 1: The in-band blocking is suggested to applied as starting point to ensure the receiver of UL sub-band is not blocked due to DL sub-band transmission (CMCC, Samsung, HW, Intel, ZTE)     - Besides blocking, LNA and dynamic range can be FFS for receiver side(ZTE, Ericsson)   + Proposal 2: AGC may be applied to adjust the receiver gain to avoid ADC saturation while impact on sensitivity. However, it seems infeasible to model this in SLS. (CMCC, Samsung, Intel)   + Note: above proposal will not preclude other study regarding this issue * Tentative agreement on dependency on gNB antenna and beam related (Question 1-5)   + Proposal 1: Gnb antenna architecture has impact on RSI mode as to achieve high spatial isolation, separate antenna panels between TX and RX chain is requested.(Samsung, HW, Intel, ZTE, QC)   + Proposal 2: TX/RX beam pair can further contribute on RSI pending on implementation. (Ericsson, Samsung , HW, Intel, ZTE)   + Proposal 3: Yes, the RSI will have dependency at least on the listed factors, but further details will need to be studied in RAN4.(Ericsson, Samsung, HW, Intel, ZTE, Nokia)   *Recommendations for 2nd round:*  *To be discussed further in reply LS and WF on RF feasibility study based on above tentative agreement* |
| *Issue 2-1-3: co-channel inter-subband gNB-gNB CLI modelling* | *Status summary:*   * Proposal on feasibility and how to model co-site gNB-gNB CLI modelling   + Option 1: For co-site gNB-gNB CLI modelling, the RSI range level proposed for self-interference cancellation shall be mandatory supported (CTC, Samsung, QC,   + Option 2: the same as inter-site gNB-gNB CLI modelling(CTC)   + Option 3: similar modelling as for self-interference but using new parameter expressing the overall isolation between Rx and Rx between co-located sectors. Assumption is same time-frequency operation between sectors. Digital interference suppression is not feasible. (CMCC, Ericsson, Intel, vivo, CATT, Nokia)   + Option 4: similar modelling as for self-interference but with different parameters(HW, ZTE) * Proposal on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity   + Option 1: UE IBE requirement based model on TX and ICS requirement based model on RX   + Option 2: gNB ACLR based model on TX and ICS requirements based model on RX (vivo, Samsung, QC)   + Option 3: gNB ACLR based model on TX and In-band blocking requirements based model on RX   + Option 4: (1/2-step) flat ACLR based model for TX and flat ACS based model with possible consideration on antenna isolation and subband filter pending on implementation (CMCC)   + Option 5: Models are valid only if receiver RF front-end operates in linear region.(Nokia)   + Option 6: Same Transmitter leakage and receiver impairment model as used for investigating gNB self-interference, but antenna isolation is replaced with inter-site isolation.(Ericsson, HW, Nokia)   ***Tentative agreement***   * Tentative agreement on feasibility and how to model co-site gNB-gNB CLI modelling:   + Proposal 1: this modelling would be different compared with inter-site gNB-gNB CLI modelling   + Proposal 2: similar modelling as for self-interference(RSI) can be applied may with different parameters especially on antenna isolation     - FFS on possibility to apply digital IC for this case * Tentative agreement on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity   + Proposal : Same Transmitter leakage and receiver impairment model as used for investigating gNB self-interference, but antenna isolation is replaced with inter-site isolation.     - TX leakage candidate: gNB ACLR     - Receiver impairment candidate: gNB ACS     - FFS on fine model with more than 1 step.   *Recommendations for 2nd round:*  *To be discussed further in reply LS and WF on RF feasibility study based on above tentative agreement* |
| *Issue 2-1-4: co-channel inter-subband UE-UE CLI model* | *Quite a lot proposal provided for this issue, and it’s suggested to provide the candidate reference requirement/model here below for 2nd round discussion.*  ***Tentative agreement***   * TX model can refer to requirement such as   + IBE(CMCC, Xiaomi, Ericsson, Samsung, HW, ZTE, vivo, CATT, Nokia, QC, MTK, Apple)   + ACLR(Ericsson, Samsung, HW) * RX model can refer to requirement such as   + ACS (Ericsson, Samsung, HW, vivo(FFS). Nokia)   + Maximum input power as threshold (vivo, CATT, Samsung, Apple)   + Estimated RX model in R4-2212562 based on no selectivity in receiver(QC, Samsung)   SNR (dB)  REFSENS + 45 dB  REFSENS + 35 dB  REFSENS  44  DL power in all RBs (dBm)  34  SNR Regime for high DL power  Figure 3.2-1: DL SNR in a receiver of a UE without in-channel selectivity  -1   * Impact due to ICI can be further studied   *Recommendations for 2nd round:*  *To be discussed further in reply LS and WF on RF feasibility study based on above tentative agreement* |
| *Issue 2-1-5: adjacent-channel gNB-gNB CLI model* | *Discussion for this issue is quite similar to co-channel co-site gNB-gNB CLI modelling. And for inter-site gNB-gNB CLI modelling, legacy ACLR and ACS based model is agreeable with slightly different view on whether fine model should be considered now.*  ***Tentative agreement***   * Tentative agreement on feasibility and how to model co-site gNB-gNB CLI modelling:   + Proposal 1: this modelling would be different compared with inter-site gNB-gNB CLI modelling   + Proposal 2: similar modelling as for self-interference(RSI) can be applied may with different parameters especially on antenna isolation(CMCC, CTC, Samsung, HW, ZTE, QC,     - FFS on possibility to apply digital IC for this case * Tentative agreement on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity with gNB ACLR based model on TX and gNB ACS requirements based model on RX   + FFS on separate calculation from ACLR and ACS perspective to address potential different antenna gain for wanted signal and unwanted signal.   *Recommendations for 2nd round:*  *To be discussed further in reply LS and WF on RF feasibility study based on above tentative agreement* |
| *Issue 2-1-6: adjacent-channel UE-UE CLI model* | *Majority view is to applied ACIR model as Rel-16 CLI as starting point. And FFS on fine model.*  ***Tentative agreement***   * Tentative agreement on feasibility and how to model UE-UE CLI modelling considering unwanted emission and receiver selectivity   + Model as starting point : UE ACLR based model on TX and UE ACS based model on RX which is the same ACIR model as Rel-16 CLI study(Ericsson, Samsung, Apple, ZTE, Nokia, QC)   + FFS on below model(preferred by CMCC, Apple, HW, ZTE, CATT)     - UE ACLR model with 2step size(FR1 example: ACLR1/2=28/33dB) on TX and UE ACS based model on RX if blocker is smaller than maximum input level of UE   *Recommendations for 2nd round:*  *To be discussed further in reply LS and WF on RF feasibility study based on above tentative agreement* |
| *Issue 2-2-1* | In 1st round discussion, all companies are supporting the co-ex study in RAN4 is needed and CLI study could be a reference, but the different view is whether SLS is needed in RAN4.  Samsung, CMCC, Huawei, ZTE, vivo, Nokia, Qualcomm expressed the views that SLS is needed in RAN4 for co-ex study.  Ericsson commented UE-UE and gNB-gNB is same as previous CLI study and can directly apply previous study conclusions, so new SLS in RAN4 may not needed. Apple, Intel and CATT wishes to discuss the differences between SBFD SLS and CLI studies. At the same time, Samsung commented the SBFD SLS study has both full number of both BSs and UEs as aggressor, while previous CLI study only have full number of UEs/BSs (100% mismatch in TR 38.828) or half BS and half UE (50% mismatch), which is different and should be simulated. CMCC and Huawei also commented the SBFD simulation is different from Rel-16 CLI simulations.  MTK asked Samsung to explain the different purposes of SLS in RAN1 and RAN4. And Samsung, CMCC, Huawei, ZTE, vivo and Nokia explained the difference in their comments that RAN1 simulation focus on system enhancements and RAN4 simulation focus on RF requirements of co-ex aspect.  Considering above, we conclude the co-ex study in RAN4 for SBFD is needed, while we encourage companies to continue expressing their views on the whether there’re differences between SBFD simulations and Rel-16 CLI simulations.  ***Tentative agreement****: Adjacent channel co-existence study in RAN4 for SBFD is needed .*  *Candidate options on SLS study in RAN4 for co-existence study*  Option 1: The SLS is needed for RAN4 co-ex study because the interference scenario is different to the Rel-17 CLI study and the study target is different to RAN1.  Option 2: The SLS is not needed for RAN4 co-ex study because the interference scenario is same with Rel-17 CLI study.  Option 3: The SLS is not needed for RAN4 co-ex study because RAN1 will conduct the study and RAN4 study purpose can be covered by RAN1 study.  *Recommendations for 2nd round:*  Further express views on above options, especially on the differences between 1) SBFD simulation and Rel-17 CLI study, and 2) RAN4 study purpose. |
| *Issue 2-2-2* | In 1st round discussion, most companies are supportive to consider Urban Macro as baseline scenario in the study, while some companies suggest to also consider RAN1 discussions and agreements. Considering above and the fact that RAN1 agreement also list Urban Macro as first priority scenario, we can conclude to consider Urban Macro as baseline scenario with high priority, and not to preclude other scenarios.  ***Tentative agreements:***  For FR1 SBFD scenarios for co-ex study:   * Consider Urban Macro as baseline scenario with high priority * Consider Indoor scenario as second priority and not preclude other scenarios.   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-3* | In 1st round discussion, most companies are supportive to consider Urban Macro as baseline scenario in the study, while some companies suggest to also consider RAN1 discussions and agreements. Considering above and the fact that RAN1 agreement also list Urban Macro as first priority scenario, we can conclude to consider Urban Macro as baseline scenario with high priority, and not to preclude other scenarios.  ***Tentative agreements:***  For FR2 SBFD scenarios for co-ex study:   * Consider Urban Macro as baseline scenario with high priority * Consider Urban Micro, Indoor scenarios as second priority and not preclude other scenarios.   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-4* | In 1st round, most companies are supporting Option 1. One company prefer Option 2, but also list Option 1 as second choice. One company asked to align with RAN1, which also pointed to Option 1. Considering above, we can agree on Option 1.  ***Tentative agreements:***  *Agree on Option 1, and not consider FR 2-2.*   * *FR1: 4GHz as exemplary frequency, FR2: 30GHz as exemplary frequency.* * *Not consider FR 2-2.*   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-5* | For TDD DL as victim, all companies are supportive to Option 1-1.  For TDD UL as victim, we have some companies supporting Option 2-1 with lower priority in study, while some companies supporting Option 2-2.  For SBFD as victim, it appears further discussion and clarifications is needed.  ***Tentative agreements:***   * Agree on Option 1-1 for TDD DL as victim.   And further discuss other options in 2nd round.  *Candidate options:*   |  |  |  |  | | --- | --- | --- | --- | | Victim | Aggressor | Aggressor baseline | Note | | NR TDD DL | SBFD | NR TDD DL in adjacent channel | Tentative agreement in 1st round. | | NR TDD UL | SBFD | NR TDD UL in adjacent channel | Option 1-1: Consider this with lower priority;  Option 1-2: TBA | | SBFD | Option 2-1:   * First priority: TDD DL * Lower priority: TDD UL * Lower priority: SBFD   Option 2-2: TBA | Option 3-1: No system in adjacent channel;  Option 3-2: SBFD in adjacent channel |  |   *Recommendations for 2nd round:*  Further discuss the above options in the table. |
| *Issue 2-2-6* | In 1st round discussion, all companies are supportive to consider the two SBFD configurations in study. Some companies prefer {DU} as worst case while some companies prefer {DUD} as starting point. One company commented if the model is frequency flat, then the two configurations will result in same adjacent channel interference. Considering above, we can conclude in general it is agreed to consider both options in option 1 at this stage, while not preclude to reduce to one configuration if two configurations are equivalent after agreed on other assumptions.  ***Tentative agreements:***  Agree on Option 1, to consider both {DUD} and {DU} configurations in this stage, while not preclude to reduce to one configuration if two configurations are equivalent for study after agreed on other assumptions.  *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-7* | All companies are supportive to Option 1, while some companies pointed out that this issue is dependent on Issue 2-2-2 and 2-2-3. Since Issue 2-2-2 and 2-2-3 has agreement to set up Urban Macro as baseline scenarios and other scenarios as second priority or not precluded, the tentative agreement of this issue can be concluded for ISD value of Urban Macro scenario.  *Tentative agreements:*  Agree on the ISD values of Option 1 for Urban Macro scenario.   * FR1 UMa with 500m ISD, FR2 UMa with 200m ISD.   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-8* | In 1st round, it has 5 companies that can go along with existing TR 38.828 channel model, while Qualcomm’s original proposal is to use 38.802/38.901 models, Ericsson proposed in 1st round to use 38.901 for UE-UE, Nokia propose to use 38.901 for BS-BS and 38.802 for UE-UE in 1st round comments.  *Tentative agreements:*  *Candidate options:*  Option 1: Re-use TR 38.828 as starting point  Option 2: Inter-gNB coupling loss can be evaluated utilizing existing gNB-UE channel models in TR 38.802/38.901 with the proper adjustments on deployment and antenna parameters to mimic a gNB-gNB scenario. (Channel model: TR 38.901, Inter-UE: TR 38.901, Inter-gNB: 38.901)  Option 3: Use 38.901 rather than 36.828 for UE-UE;  Option 4: Use 38.901 for BS-BS, and use 38.802 for UE-UE.  *Recommendations for 2nd round:*  Further discuss the technical differences between different channel models.  Recommends to agree on Option 1 as starting point and further discuss the models in next meetings. |
| *Issue 2-2-9* | As pointed out by some companies, the 0% grid shift case here is overlapping with the discussion in Issue 2-1-3 and 2-1-5, please continue discussion in those issues first, and we can come back later.  For the others, all companies are supporting 100% grid-shift considered for study, and some company also supporting other non-zero grid shift if needed.  Considering above, we can conclude 100% grid-shift case is agreed to be considered as starting point, while other non-zero grid shift cases are not precluded.  ***Tentative agreements****:*  Agree to consider 100% grid shift as starting point, while other non-zero grid shift cases are not precluded.  *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-10* | In 1st round, the discussions are quite diverse. And it can be further grouped into 3 sub topics for further discussion in 2nd round.  *Tentative agreements:*  *Candidate options:*  **For Indoor/Outdoor UE ratio:**  Option 1-1: Re-use TR 38.828, which means FR1 Macro-to-Macro uses 20% indoor and 80% outdoor; FR2 Macro-to-Macro uses 0% indoor, Micro-to-Micro uses 80% indoor and 20% outdoor;  Option 1-2: For Macro-to-Macro cases of both FR1 and FR2, assume 80% indoor and 20% outdoor ratio.  **For UE distribution mechanism:**  Option 2-1: Evenly random dropping in service area;  Option 2-2: Consider clusters in UE dropping.   * + Step 1: Randomly drop a cluster within a macro cell geographical area considering the minimum distance between macro TRP to cluster centre, e.g., 100m , where the size of each cluster is 120 x 50 (m);   + Step 2: 80% UEs are randomly and uniformly dropped within the cluster, and 20% UEs are randomly and uniformly dropped outside the cluster.   **For number of UE considered in study:**  Option 3-1: user number s per transmission reception point should equal to the number of sub-bands, i.e. 2 UEs for {DU} subband config, 3 UEs for {DUD} config.  Option 3-2: more than 1 UE per TRP for FR1.  *Recommendations for 2nd round:*  Further discuss all above options for different sub-topics to agree on a starting point at least. |
| *Issue 2-2-11* | In 1st round discussion, all companies are supporting Option 1, while one company suggest different NF values for FR1 indoor BS. Given the ‘Indoor’ case is agreed in Issue 2-2-2 as second priority, we can at least conclude the NF for Macro BS of FR1 and FR2 based on Option 1.  ***Tentative agreements:***  For Macro case, agree on Option 1.   * Re-use TR 38.828 assumptions -- FR1 BS: 5dB, UE: 9dB; FR2 BS: BS: 10dB, UE: 10dB.   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-12* | In the 1st round, we have two companies supporting to consider both Option 1-1 and Option 1-2 in Option 1, one company prefer Option 1-1, and one company suggest to consider both options decide with specific values later. And, there is one company supporting Option 5. Considering above, we suggest to focus discussing between Option 1 and Option 5 in 2nd round discussion.  *Tentative agreements:*  *Candidate options:*  Option 1: Re-use TR 38.828 for legacy TDD BS, and consider two options for SBFD BS antenna and TRP power (specific values are described in previous Option 1)  Option 2: Use extended AAS model defined in TR 38.803, Table 5.2.3.2.4-2 as the sub-array is essential to be able to provide TX/RX isolation required for SBFD. For FR1 parameters in TR 38.803, Table 5.2.3.2.4-3 is proposed as starting point. Parameters for FR2 is proposed as Table 4 in R4-2212620.  *Recommendations for 2nd round: N/A*  Discuss and agree on one antenna model. And the specific values, like element number and Tx power, can be square-bracketed as starting point. |
| *Issue 2-2-13* | In 1st round discussion, all companies have supported FR1 part of Option 1. We can conclude FR1 part of Option 1 as agreed, while keep discussing FR2 part in 2nd round.  ***Tentative agreements:***  Agree on FR1 UE antenna and Tx power from Option 1.   * Re-use TR 38.828 assumptions -- FR1 max Tx 23dBm, min Tx -40 dBm with 0dBi omni directional antenna.   *Candidate options:*  **For FR2,**  Option 1: Re-use TR 38.828 assumptions -- - FR2 max Tx 13.4dBm (peak eirp 22.4dBm), min Tx -40dBm, with antenna configuration in below table  Option 2: FR2 max Tx 23dBm (peak eirp 43dBm) with (M, N, P)=(1, 4, 2), 2 panels antennas and element gain as 1.5 dBi  *Recommendations for 2nd round:*  Further discuss above options. |
| *Issue 2-2-14* | In 1st round, 5 companies are supporting the combination of Option 1 and 2, while one company suggest an new option 3 that it should be determined with array parameters as a package per considered deployment scenario. Considering above, we will combine the original Option 1 and 2 as one new option, and encourage the discussion between this new option and the Option 3 in 2nd round.  *Tentative agreements:*  *Candidate options:*  Option 1: Use 6 degrees for Macro BS for FR1 and FR2 as provided in TR 38.803, and 90-deg (point to ground) for indoor.  Option 2: Mechanical tilt should be determined together with array parameters as a package per considered deployment scenario.  *Recommendations for 2nd round:*  Further discuss above options. |
| *Issue 2-2-15* | ***Tentative agreements:***  Option 1: Propose to use the following as the general uplink power control model for SBFD co-existence study.   |  | | --- | | For downlink scenario, no power control scheme is applied.  For uplink scenario, TPC model specified in Section 9.1 TR 36.942 [9] is applied with following parameters.  - CLx-ile = –SNR\_target + UE\_maxpower – ThermalNoise – BS\_NoiseFigure + 10\*log10(BW)  - γ = 1  Where, SNR\_target for FR1 and FR2 are 15 dB. |   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-16* | Given the discussion is overlapping with Issue 2-1-6, please refer to the discussion in Issue 2-1-6.  *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  Refer to discussion in Issue 2-1-6. |
| *Issue 2-2-17* | ***Tentative agreements:***  Option 1: Re-use TR 38.828 assumptions -- ACLR/ACS for FR1 BS: 45/46 dBc, FR2 BS: 28/23.5 dBc.  *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-18* | In 1st round discussion, all companies are OK to have Option 1 as starting point.  ***Tentative agreements:***  Agree on Option 1 as starting point.   * Option 1: Proposed to use {N = noise floor + 1dB} for the SBFD system to simulate the self-interference impact as a simplified method to evaluate its SINR/throughput.   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-19* | In 1st round discussion, most companies are OK with Option 1.  Two companies commented the self-interference needs to be considered. The Issue 2-2-18 agreements, N=noisefloor+1dB is supposed to be added to the equations in this Option 1 when evaluating SBFD. With this, the self-interference is considered.  One company support the framework while concerned with the evaluation baseline and victim-aggressor combinations, this will be covered by discussion in Issue 2-2-5.  With above, we conclude the Option 1 is agreeable.  ***Tentative agreements:***  Agree on Option 1 with the noise floor of SBFD as {N = noise floor + 1dB} (Issue 2-2-18 agreements)  Option 1: Propose to adopt the following steps, modified from TR 38.828 and other general legacy RAN4 coex study report, as the simulation steps for SBFD coex study.   |  | | --- | | 1. Aggressor and victim network are generated.  - UEs are distributed randomly across the network.  2. UE associations: UEs are associated to base station based on coupling loss.  - Associations are made assuming a single element at both UE and BS.  3. Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-UE. This is done for both victim and aggressor networks.  4.  When legacy TDD system is victim, follow steps 4a:  4a. Throughput is computed considering ACI from another static TDD system as baseline aggressor:  - , where is the inter-cell interference and is the adjacent channel interference from the baseline aggressor.  When SBFD system is victim, follow steps 4b:  4b. Throughput is computed in the victim system without considering ACI as below:  - , where is the inter-cell interference.  5. Throughput is computed considering ACI below:  - , where is the adjacent channel interference. |   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Issue 2-2-20* | In 1st round, 8 companies support Option 1, while 2 companies suggested new metrics in RAN4 study, such as latency and coverage improvement, as additional to Option 1. One company suggest discussing the difference from RAN1, which is also discussing under Issue 2-2-1.  With above, we can conclude Option 1 as agreeable, and further discuss the additional new metrics in 2nd round.  ***Tentative agreements****:*  Option 1: It is proposed to follow the TR 38.828’s evaluation criteria to check the 50% and 5% throughput loss compared to the baseline scenario defined.  *Candidate options:*  Option 1: In addition to throughput loss, consider new metrics such as latency and coverage improvement.  Option 2: TBA.  *Recommendations for 2nd round:*  Further discuss the new option 1 and 2. |
| *Issue 2-2-21* | In 1st round, 6 companies are supporting Option 1 and WF, while 1 company suggest to also consider RAN1 evaluation as needed. Given the existing wording in Option 1 and WF described it as a starting basis, and should be updated accordingly to fulfill the study purpose, the WF does not preclude any current and future meeting discussions and/or modifications to the TR 38.828 assumptions. It should be able to solve the concern.  ***Tentative agreements:***  Agree on Option 1 as a general starting basis for those SLS assumptions that were not discussed.   * Option 1: Propose to adopt the system characteristics, deployment parameters and other assumptions from TR 38.828 as the starting point for SBFD co-ex study. But the assumptions should be updated accordingly to fulfill the SBFD co-ex purpose.   *Candidate options:*  *Recommendations for 2nd round: N/A* |
| *Sub-topic#2-3-1* | *Status summary:*  *The LLS could be considered as part of RAN4 feasibility study which can be captured in TR which should be contribution driven. However, it should not preclude quick reply according to RAN1 request which is consensus based. And the alignment of model for evaluation based on realistic implementation is timing consuming and even impossible as in legacy similar study. Hence there are concerns shared on this aspect.*  *Candidates option:*  *RAN4 need to discuss further and organize related study with constructive way to improve the efficiency*  *Recommendations for 2nd round:*   * *To be discussed in WF on RF feasibility study* |

*Annex: update on RIS summary table according to round1 feedback(in change mark).*

Table 2-1-1: Summary table for FR1

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Factors | R4-2211562 | R4-2212493 | R4-2212486 | R4-2212620 | R4-2212848 | R4-2213690  For Medium range BS | R4-2212117/Kumu |
| Spatial isolation | 80 dB  Separated panel | 80 dB | 70 -80 dB  Separated panel | 65 dB in large enough BW | 100+ dB needed for Macro, feasibility FFS , | 50 dB | >70 dB |
| Frequency isolation | 45 dB | 45 | 45 dB | 45dB as commented in 1st round | 45 dB  With guard band | 45 dB | 45 dB |
| Beam nulling /isolation | 5~10 dB | TX beam:10 dB  RX beam:10 dB | ~10 dB | - | FFS | - | 30-40dB together with RF cancellation |
| Digital IC | 10~15 dB | 10 dB | 30-50 dB | - | FFS | [30] for digital IC or transmitter sub-band filtering |  |
| Overall RSIC | 140~150 dB  as capable | 145 dB | 140 – 185 dB as capable | - | 100+ dB needed for Macro | 125 dB | >100 dB |

Table 2-1-2: Summary table for FR2-1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | R4-2211562 | R4-2212493 | R4-2212486 | R4-2212848 | R4-2213690 | Kumu |
| Spatial isolation | 80-90 dB  Separated panel | 85~95 | 90-120 dB  Separated panel | Shared antenna is not feasible | 96 dB | 80-90dB |
| Frequency isolation | 28 dB | 28 dB | 30 dB | 22.5 dB | 28 dB | 28dB |
| Beam nulling /isolation | 5~10 dB | TX beam:10 dB  RX beam:10 dB | ~5 dB | FFS |  | 30-40dB together with RF cancellation |
| Digital IC | 10 dB | - | 30 -50 dB | FFS |  |  |
| Overall RSIC | 120-140 dB | 123 dB | 145 – 205 dB | - | 124 dB |  |

### CRs/TPs

*NA*

## Discussion on 2nd round (if applicable)

*Moderator can provide summary of 2nd round here. Note that recommended decisions on tdocs should be provided in the section titled ”Recommendations for Tdocs”.*

Comment to WFs and LS draft directly

# Topic #3: Regulatory survey

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2211881 | Apple | Observation 1: The focus of RAN4 task of summarizing the regulatory aspects is to find out if there is any regulation that limits such simultaneous TX and RX by a gNB on TDD spectrum.  Proposal 1: If needed, consider using direct liaison with regulatory bodies to obtain relevant regulatory info/clarification. |
| R4-2212314 | CMCC | **Regulatory information from China:**  Observation 1: In China, spectrum is allocated with clearly stating it for TDD or FDD operation. There is no SBFD regulatory requirements in China now.  Observation 2: MIIT mainly cares interference between different operators. Necessary interference coordination mechanism and solutions may be proposed by MIIT to avoid interference before any SBFD deployment. |
| R4-2212495 | Huawei, HiSilicon | **Observation based on 3GPP specification and Europe regulatory:**  Observation 1: for TDD multiple operators’ networks, it requires synchronized operation for using the same or adjacent operation band.  Observation 2: It already possible today to use different TDD frame structure for isolated deployment, e.g. isolated indoor factory, as long as obligation to avoid interference is guaranteed.  Observation 3: for single operator’s TDD network, there may be no limitation on the frame structure and it is up to operator’s choice. |
| R4-2212580 | Samsung R&D Institute UK | **Observation based on Europe regulatory:**  Observation 1: The evolution of NR duplex operation would bring changes to the frame structures of legacy TDD operation and consequently may affect TDD synchronisation.  Observation 2: Several frame structures for TDD MFCN networks have been recommended by ECC to facilitate synchronisation in the frequency band 3400-3800 MHz.at boarder areas. However, unsychronised or semi-synchronised operation of TDD MFCN networks are not precluded with certain requirements and/or procedures of cross-boarder coordination between administrations. |
| R4-2212655 | Ericsson | **Survey on regulatory from Europe, North America, China and Japan:**  Observation 1: For a chosen TDD pattern, sub-band full duplex operation would increase the UL transmission in the network, increasing the level of UL interferences.  Observation 2: Regulators made coexistence studies assuming a certain DL/UL ratio. Any change in that ratio might have some impacts on the corresponding studies’ conclusion.  Observation 3: To authorize SBFD deployment, Regulators might want to re-evaluate existing coexistence studies done for TDD bands, releasing a new regulation.  Observation 4: For some 5G bands, Regulators have considered unsynchronized (or semi-synchronized) TDD operation between adjacent operators by introducing more stringent parameters  Observation 5: More stringent Regulatory requirements might impact BS feasibility, final cost, size and weight, especially if SBFD DL is considered during “legacy” UL slots. |
| R4-2212849 | Nokia, Nokia Shanghai Bell | **Observation based on Europe regulatory**  Proposal 1: focus the study on regulatory aspects for deploying the identified duplex enhancements to the TDD unpaired spectrum in the 3400-3800 MHz frequency range.  Observation 1: In many CEPT countries, the same frame format is effectively mandated both indoor and outdoor in the 3400-3800 MHz frequency band.  Observation 2: In other regions, synchronization in the 3400-3800 MHz frequency band is not mandated but highly recommended.  Proposal 2: Approve TP to the TR 38.585 |

## 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 3

*Sub-topic description:*

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

#### Issue 3-1: Survey on regulatory aspects

* Summary according to input for this meeting
  + Summary on CEPT countries
    - Regulators made coexistence studies assuming a certain DL/UL ratio for IMT TDD band 3.4-3.8GHz band in Europe. The evolution of NR duplex operation would bring changes to the frame structures of legacy TDD operation and consequently may affect TDD synchronisation.(R4-2212580/R4-2212655/R4-2212849)。
    - In many CEPT countries, the same frame format is effectively mandated both indoor and outdoor in the 3400-3800 MHz frequency band.(R4-2212849)
    - Several frame structures for TDD MFCN networks have been recommended by ECC to facilitate synchronisation in the frequency band 3400-3800 MHz at boarder areas. However, unsynchronised or semi-synchronised operation of TDD MFCN networks are not precluded with certain requirements and/or procedures of cross-border coordination between administrations. (R4-2212580)
    - It already possible today to use different TDD frame structure for isolated deployment.(R4-2212495)
  + Summary on North America(R4-2212655):
    - No TDD pattern has been mandated in US, nor in Canada, but operators are encouraged to coordinate their network deployment and make sure they don’t interfere with each other.
    - Unsynchronized operation is allowed, more stringent regulation parameters have not been specified for such case but, again, operators would have to work their differences to avoid any claim to FCC/ISED.
  + Summary on China (R4-2212314/R4-2212655):
    - In China, spectrum is allocated with clearly stating it for TDD or FDD operation. there is no SBFD regulatory requirements in China until now.
    - MIIT mainly cares interference between different operators. Necessary interference coordination mechanism and solutions may be proposed by MIIT to avoid interference before any SBFD deployment.
  + Summary on Japan (R4-2212655):
    - No TDD pattern has been mandated in Japan but operators are required to coordinate their network deployment to avoid interference.
    - Operators are allowed to use unsynchronized operation as far as there is no interference with the adjacent network(s), e.g. for indoor usage.
* Recommended WF
  + Please comment if any different understanding regarding regulatory aspect for each region/country on SBFD operation

|  |  |
| --- | --- |
| Company | Comments |
| Ericsson | We just want to clarify in the moderator’s summary that, in CEPT countries, if unsynchronized or semi-synchronized operations are indeed allowed in the 3.4GHz band, CEPT has specified corresponding more stringent requirements (also called “restricted baseline”) to enable such deployment, in the absence of operators’ agreement/cooperation. |
| China Telecom | Agree with Summary on China. |
| Nokia, Nokia Shanghai Bell | Related to the statement that it is different TDD frame structure for isolated deployments in some CEPT countries (R4-2212495), it is our understanding that this is only possible assuming more restrictive requirements with consequent impacts on gNB cost and complexity. |

#### Issue 3-2: Proposal to study on regulatory aspect

* Proposals
  + Option 1: discuss the necessity to consider direct liaison with regulatory bodies to obtain relevant regulatory info/clarification.(R4-2211881)
  + Option 2: focus the study on regulatory aspects for deploying the identified duplex enhancements to the TDD unpaired spectrum in the 3400-3800 MHz frequency range.(R4-2212849)
  + Option 3: clarify further the difference between SBFD and CLI operation in view of regulatory from interference perspective
* Recommended WF
  + Please comment to each option

|  |  |
| --- | --- |
| Company | Comments |
| CMCC | For option 2, if we want to narrow down the regulatory spectrum range, 2496-2690MHz and 4400-5000MHz are also suggested to be involved.  Option 1 and option 3 are both OK for us. |
| Ericsson | Regarding option 1, we think this is too early now but might be considered later. Before liaising with Regulators, RAN4 should better identify and quantify the expected impacts when introducing SBFD.  Option 2 would be too restrictive, other bands should also be considered. But this could be the starting point. |
| Samsung | The summary on regulatory aspect with respect to SBFD operation for each region/country is provided in issue 3-1. If there is no mistake and it’s all pubic available information we can collect so far according to feedback from companies, there may be no need to inquire regulatory bodies since no further information can be expected. But RAN4 may check the necessity proposed in option 1 later.  Furthermore, we do believe in view of async operation perspective, SBFD and CLI operation should share the similarity in regulatory body. Hence all the CLI conclusion on regulatory perspective should be applicable for SBFD operation somehow.  Regarding proposal in option 2, the SI covers both sub6GHz and MMW, we would like to understand that whether this proposal implies that there is no restriction from regulatory perspective to deploy SBFD operation in FR2? |
| Apple | We can use Option 1 when RAN4 identifies the need. For Option 2, we are not sure if we should focus on a specific band at the beginning, but we are open to considering it if there is good support. For Option 3, further clarification is needed on what CLI operation means. |
| Huawei | Option1: we agree with other companies that it is too early now and we can consider it later.  Option 2: there is no need to restrict to one range at current stage. |
| ZTE | Option 1: if necessary, we could send the LS to regulatory body to check it, however as mentioned by other companies, the timeline could be further discussed.  Option 2: there is not necessity to restrict on single frequency range. |
| Nokia, Nokia Shanghai Bell | We essentially support all options. Related to Option 1, we think direct liaison with regulatory bodies is a good approach to obtain relevant clarifications. Related to Option 2, proposed to focus on TDD unpaired spectrum in the 3400-3800 MHz frequency range as the 3.5 GHz band has clearly raised in recent year as the principal/global 5G band. Related to Option 3, we think RAN4 should clarify the difference (if any) between SBFD and dynamic TDD in view of regulatory aspects from interference perspective. |
| Qualcomm | With evolution to dynamic/flexible TDD, there is inter-gNB CLI and inter-cell inter-UE CLI, however with evolution to SBFD deployments, there is additional inter-subband inter-gNB CLI and inter-subband both inter cell and intra cell inter-UE CLI. RAN4 needs to understand first the discrepancies in terms of experienced interference compared to dynamic TDD and CLI operation to better understand the regulatory perspective.  For option 1, discussion is still in an early stage to liase with regulatory bodies. This should be conducted once RAN4 understood the feasibility of SBFD deployments and its implications compared to legacy and dynamic TDD deployments. For option 2, the SI on duplex evolution is targeting both FR1 and FR2, so it is not clear why to focus the regulatory discussion now only at 3.4-3.8 GHz band. |

## Companies views’ collection for 1st round

### CRs/TPs comments collection

*For this Rel-18 SI, suggest to focus on open issues discussion in the first meeting and postpone the approval on TP according to work plan.*

## 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#3** | *Status summary:*   * *Except minor clarification on ETSI regulation it seems no other comment on regulatory survey summary in issue 3-1* * *No common understanding on options provided in issue 3-2*   *Recommendations for 2nd round:*   * *Since no further input expected on existing regulation perspective it’s suggested to stop discussion in 2nd round for this aspect.* * *Further study is invited in future meeting* |

### 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)

*NA*

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |  |
| --- | --- | --- | --- |
| **New Tdoc number** | **Title** | **Source** | **Comments** |
|  | *Reply LS on interference modelling for duplex evolution* | Samsung | To: RAN\_1 |
|  | *WF on feasibility study from RF perspective* | Samsung | *Cover sub topic 2-1 and 2-3* |
|  | *WF on adjacent channel co-existence study* | Samsung | *Cover issue 2-2-1/2/3/5 in sub-topic 2-2* |
|  | *WF on Simulation assumption for adjacent co-existence study* | CMCC | *Cover issue other than 2-2-1/2/3/5 in sub-topic 2-2* |

**Existing tdocs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-2211561 |  | Impact of SBFD on RF requirements for co-existence in adjacent channel | Qualcomm CDMA Technologies | To be noted |  |
| R4-2211562 |  | Impact of SBFD on RF requirements for self-interference and CLI | Qualcomm CDMA Technologies | To be noted |  |
| R4-2211709 |  | Discussion of the reply LS to RAN1 on interference modelling for duplex evolution | CATT | To be noted |  |
| R4-2211710 |  | Preliminary discussion of the adjacent channel co-existence for SBFD | CATT | To be noted |  |
| R4-2211711 |  | Preliminary discussion on the self-interference and CLI for SBFD | CATT | To be noted |  |
| R4-2211790 |  | Discussion on RF requirements for subband full duplexing | CEWiT |  | Not available |
| R4-2211880 |  | On UE-UE CLI modeling | Apple | To be noted |  |
| R4-2211881 |  | On regulatory aspects of evolution of NR duplex operation | Apple | To be noted |  |
| R4-2212117 |  | Discussion on RF requirement for Massive MIMO Antenna for subband non-overlapping full duplex | Kumu Networks | To be noted |  |
| R4-2212146 |  | Views on RF Analysis for Full Duplex | Intel Corporation | To be noted |  |
| R4-2212160 |  | Duplex enhancements UE-UE CLI modelling | MediaTek (Chengdu) Inc. | To be noted |  |
| R4-2212161 |  | Clarifying RAN4 work scope for duplex enhancements | MediaTek (Chengdu) Inc. | To be noted |  |
| R4-2212312 |  | self interference and CLI study of SBFD | CMCC | To be noted |  |
| R4-2212313 |  | adjacent channel interference analysis for SBFD | CMCC | To be noted |  |
| R4-2212314 |  | SBFD regulatory requirements in China | CMCC | To be noted |  |
| R4-2212485 |  | Initial observations on RF impact due to NR duplex evolution | Samsung | To be noted |  |
| R4-2212486 |  | Discussion on interference modelling for duplex evolution | Samsung | To be noted |  |
| R4-2212487 |  | Workplan on NR duplex evolution for RAN4 | Samsung,CMCC | To be revised |  |
| R4-2212492 |  | On evolution of NR duplex operation | Huawei, HiSilicon | To be noted |  |
| R4-2212493 |  | Reply LS on interference modelling for duplex evolution | Huawei, HiSilicon | To be noted |  |
| R4-2212494 |  | Discussion on the assumptions for co-existence evaluation of Rel-18 duplex evolution | Huawei, HiSilicon | To be noted |  |
| R4-2212495 |  | On regulatory aspects | Huawei, HiSilicon | To be noted |  |
| R4-2212580 |  | Discussion on regulatory aspect of NR duplex evolution | Samsung R&D Institute UK | To be noted |  |
| R4-2212599 |  | Discussion on interference modelling for duplex evolution | Xiaomi | To be noted |  |
| R4-2212619 |  | General considerations for the duplexng enhancements RAN4 work and draft reply LS to RAN1 | Ericsson | To be noted |  |
| R4-2212620 |  | Co-channel gNB self interference analysis | Ericsson | To be noted |  |
| R4-2212621 |  | Co-existence considerations for SBFD | Ericsson | To be noted |  |
| R4-2212655 |  | Sub-Band Full Duplex - Regulatory aspects | Ericsson | To be noted |  |
| R4-2212697 |  | Scenarios, assumptions and analysis for SBFD coex study | Samsung | To be noted |  |
| R4-2212801 |  | Discussion on co-existence in adjacent channel for full duplex | vivo | To be noted |  |
| R4-2212802 |  | Discussion on self-interference and CLI for full duplex | vivo | To be noted |  |
| R4-2212847 |  | Adjacent channel coexistence in Sub Band non-overlapping Full Duplex operation | Nokia, Nokia Shanghai Bell | To be noted |  |
| R4-2212848 |  | Self-interference and CLI in Sub Band non-overlapping Full Duplex | Nokia, Nokia Shanghai Bell | To be noted |  |
| R4-2212849 |  | Regulatory considerations on sub-band full duplex operation | Nokia, Nokia Shanghai Bell | To be noted |  |
| R4-2213690 |  | Discussion on reply LS for full duplex BS | ZTE Corporation | To be noted |  |
| R4-2213691 |  | Discussion on full duplex coexistence in adjacent channel scenario | ZTE Corporation | To be noted |  |
| R4-2213692 |  | Discussion on self-interference and CLI for full duplex BS | ZTE Corporation | To be noted |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics incl. existing and new tdocs.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. For new LS documents, please include information on To/Cc WGs in the comments column
4. Do not include hyper-links in the documents

## 2nd round

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tdoc number** | **Revised to** | **Title** | **Source** | **Recommendation** | **Comments** |
| R4-22xxxxx |  | CR on … | XXX | Agreeable, Revised, Merged, Postponed, Not Pursued |  |
| R4-22xxxxx |  | WF on … | YYY | Agreeable, Revised, Noted |  |
| R4-22xxxxx |  | LS on … | ZZZ | Agreeable, Revised, Noted |  |
|  |  |  |  |  |  |

Notes:

1. Please include the summary of recommendations for all tdocs across all sub-topics.
2. For the Recommendation column please include one of the following:
   1. CRs/TPs: Agreeable, Revised, Merged, Postponed, Not Pursued
   2. Other documents: Agreeable, Revised, Noted
3. Do not include hyper-links in the documents