**3GPP TSG RAN WG1 #109-e**  **R1-22xxxxx**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.3.1

**Source:** Moderator (CMCC)

**Title:** Summary# of email discussion on evaluation of NR duplex evolution

**Document for:** Discussion/decision

# Introduction

The SI Study on evolution of NR duplex operation was approved in RAN plenary #94-e meeting [1], and the SID was revised in RAN plenary #95 e-meeting [2].

The following email thread for AI 9.3.1 Evaluation on NR duplex evolution is announced by chairman in RAN1#109-e:

[109-e-R18-Duplex-02] Email discussion on evaluation of NR duplex evolution by May 20 – Fei (CMCC)

* Check points: May 12, May 18, May 20

In this contribution, we summarized the related issues and proposals based on the contributions submitted in RAN1#109-e under the agenda item 9.3.1 [3]-[25].

The following sections are structured as follows. From section 2 to 5, we categorize the key issues raised by contributions into 4 kinds and some sections may cover more than one sub-issue. For each issue/sub-issue, we provide the background and related proposals, the summary of the proposals, and initial proposals/questions suggested by moderator in sub-sections. For each identified proposal/question, one table is provided to collect company views during the email discussion. In section 6, some proposals will be selected for discussion in the GTW session.

If possible, please try to provide your replies within 24h. Moderator will try to update the proposals based on companies’ inputs on a daily basis.

# Issue#1: Deployment scenarios for SBFD

## Background and submitted proposal

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| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1:*** *Focus on the following scenarios for SBFD evaluation:*   * *Scenario A1 (FR1, FR2): Indoor hotspot with common UL/DL subband configuration* * *Scenario A2 (FR1, FR2): Urban Micro or Dense Urban micro layer with common UL/DL subband configuration* * *Scenario A3 (FR1): Urban Macro with common UL/DL subband configuration* * *Scenario C3 (FR1): Urban Macro considering co-channel co-existence with legacy TDD operation* * *Scenario D3 (FR1): Urban Macro considering adjacent-channel co-existence with legacy TDD operation*   ***Observation 3:*** *For Scenario C3 (Urban Macro considering co-channel co-existence with legacy TDD operation), no system level simulation is needed, and the DL performance impact of SBFD operation on the legacy TDD can be simply analyzed based on the reduction of the available DL frequency resources due to resource muting for legacy TDD.*  ***Proposal 25:*** *No system level simulation is needed for Scenario C3 (Urban Macro considering co-channel co-existence with legacy TDD operation).*  ***Proposal 26:*** *It is not necessary for RAN1 to perform the performance evaluation for adjacent-channel co-existence between SBFD operation and legacy TDD operation.* |
| Huawei | ***Observation 2****: Low latency is the dominant benefit for subband non-overlapping full duplex under the factory/industry deployment scenario.*  ***Observation 3****: Better uplink coverage is the dominant benefit for subband non-overlapping full duplex under the Macro deployment scenario.*  ***Proposal 3****: Scenario 3-3 should be studied with a high priority for subband non-overlapping full duplex.*   * *Scenario 3-3: Factory/industry Pico with subband non-overlapping full duplex (and potential Macro with DL dominant TDD configuration) (FR1 only).*   ***Proposal 4****: Scenario 1-3 should be studied with a high priority for subband non-overlapping full duplex.*   * *Scenario 1-3: Macro with subband non-overlapping full duplex with same resource configurations (FR1 and FR2).*   ***Proposal 5****: The following deployment scenarios can be studied after the evaluation of other scenarios:*   * *Scenarios 4: Macro with subband non-overlapping full duplex and Macro with legacy TDD configuration on the same carrier (co-channel co-existence with legacy base stations scenarios);* * *Scenarios 5: Macro with subband non-overlapping full duplex and Macro with legacy TDD configuration on the adjacent carriers (adjacent-channel co-existence or inter-operator co-existence scenarios).* |
| ZTE | ***Proposal 1****: Perform thorough analysis and study for sub-band non-overlapping duplex in Rel-18 to lay the foundation for future duplex study for both 5G and 6G.*  ***Proposal 3****:* *Rel-18 duplex evolution considers the following 6 challenges of legacy TDD system and evaluate the potential gain of subband full duplex.*   * *Challenge ①: Ensuring UL throughput + UL coverage simultaneously.* * *Challenge ②: Ensuring UL throughput + DL&UL Latency simultaneously.* * *Challenge ③: Ensuring UL coverage + DL&UL Latency simultaneously.* * *Challenge ④: Ensuring DL throughput + DL&UL Latency simultaneously.* * *Challenge ⑤: Ensuring DL throughput + UL throughput simultaneously.* * *Challenge ⑥: Ensuring DL throughput + UL coverage simultaneously.*   ***Proposal 4****: RAN1 studies at least the following scenarios in Rel-18 duplex SI*   * *For subband full duplex: urban macro, dense urban, indoor hotspot and urban macro + indoor hotspot (optional).* * *For dynamic/flexible TDD: dense urban, and urban macro + indoor hotspot*   ***Proposal 5****: RAN1 studies the following potential deployment for dynamic TDD and subband full duplex.*   * ***Deployment#1 (1st priority)****: Dynamic TDD, all the gNBs are legacy TDD gNB in the same channel with two different TDD slot formats.* * ***Deployment#2 (1st priority)****: Subband full duplex, all the gNBs are subband full duplex gNB in the same channel with the same time/frequency pattern without any co-existence co-channel or adjacent channel interference.* * ***Deployment#3 (1st priority)****: Subband full duplex, all the gNBs in channel#1 are subband full duplex gNB with the same time/frequency pattern. There are also other legacy TDD gNBs in adjacent channel#2.* * ***Deployment#4 (1st priority)****: Subband full duplex, some gNBs in channel#1 are subband full duplex gNB with the same time/frequency pattern. There are also other legacy TDD gNBs in channel#1.* * ***Deployment#5 (2nd priority)****: Subband full duplex, gNBs in channel#1 are subband full duplex gNB with the different time/frequency patterns.* * ***Deployment#6 (2nd priority)****: Isolated case. There is only one single subband full duplex gNB without any interference from other co-channel or adjacent channel gNBs.* |
| New H3C | ***Proposal 4:*** *The following duplex mode options are considered for on NR duplex evolution.*   * *Case 1: Dynamic duplex mode*   *Any resource in duplex manner can be changed dynamically between DL and UL. In the evaluation, depending on the incoming traffic and the scheduler decision, any suband in the slots/symbols for duplex mode can carry DL or UL traffic.*  *Operation based on dynamic TDD is expected to cause so-called cross-link interference where the dominant interference for a transmission in one direction (e.g., downlink) is caused by another transmission in the other direction (e.g., uplink).*   * *Case 2: Static duplex mode*   *A coordinated scheme where the DL:UL ratio for the allocated duplex mode slots/symbols is fixed for some period of time and the same DL:UL ratio is used by all nodes in the network. This scheme for the allocated duplex mode slots/symbols is equivalent to the traditional legacy FDD. In other words, the DL:UL ratio for the allocated duplex mode slots/symbols is the same and synchronous across all the nodes in the network.*  *Operation based on static duplex mode is immune to so-called cross-link interference while the DL to UL ratio for the allocated duplex mode slots follows a static or semi-static structure that is matched to the long-term statistics of the incoming DL to UL traffic ratio.* |
| Spreadtrum Communications, BUPT | ***Proposal 1:*** *For evolution of duplex operation, isolated/non-isolated indoor factory, Macro & indoor factory and urban Macro are recommended as evaluation scenarios.*   * *For the first step, non-isolated factory and urban Macro with the same subband configuration are recommended as the highest priority candidate scenarios.* |
| CATT | ***Proposal 1:*** *The deployment scenarios for SBFD evaluation include indoor hotspot, dense urban and urban macro.*  ***Proposal 5:*** *For SBFD evaluation, prioritize the case that subband configuration across all the cells operating SBFD is the same.*  ***Proposal 13:*** *Co-channel co-existing of SBFD with legacy TDD is studied in RAN1 and adjacent channel co-existence is led by RAN4.* |
| vivo | *Proposal 1: For SBFD and dynamic TDD evaluation, system-level simulation assumptions in TR 38.828 can be used as a starting point.*  *Proposal 2: For non-coexistence* *scenarios in SBFD or dynamic TDD evaluation, UMa, 1-layer DU and InH can be high priority.*  *Proposal 3: 100% grid-shifted deployment of gNB can be used for multiple operators’ co-existence scenarios.*  *Proposal 4: For co-coexistence scenarios in SBFD or dynamic TDD evaluation, UMa, 1-layer DU and InH, can be considered.*  ***Proposal 7:*** *For fair comparison between semi-static SBFD and semi-static TDD, the DL-to-UL resource ratio is assumed to be the same.*  ***Proposal 8:*** *For SBFD with dynamic frequency format, the baseline is case 2-1.* |
| xiaomi | ***Proposal 1:*** *For subband non-overlapping full duplex, performance evaluation should be done at least in the indoor/hotspot, dense urban and macro urban scenarios.*  ***Proposal 2:*** *For evaluation of subband non-overlapping full duplex, co-existence between legacy gNB and duplex gNB in the same network should be considered.*  ***Proposal 4:*** *For evaluation of SBFD, the following two cases should be considered for each identified scenarios to evaluate the uplink performance:*   * *Indoor hotspot*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration* * *Dense urban*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration* * *Urban Macro*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration* * *Co-channel co-existence of duplex gNB and legacy gNB*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration + legacy TDD*   ***Proposal 5:*** *For evaluation of SBFD, the following two cases should be considered for each identified scenarios to evaluate the downlink performance:*   * *Indoor hotspot*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration* * *Dense urban*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration* * *Urban Macro*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration* * *Co-channel co-existence of duplex gNB and legacy gNB*   + *Baseline: DL dominated TDD w/o CLI*   + *Duplex case: common UL subband configuration + legacy TDD* |
| Samsung | *Proposal 1: For evaluation purpose, the following three categories of applicable scenarios can be evaluated with their priorities.*   * *The non-coexistence applicable scenario with highest priority* * *The coexistence applicable scenario of static TDD and a new duplex operation with medium priority* * *The coexistence applicable scenario of two new duplex operations with low priority*   *Proposal 2: For non-coexistence applicable scenario, RAN1 takes the following applicable scenarios as a baseline*   * *Indoor hotspot (FR1/FR2) with SBFD-only deployment and dynamic/flexible TDD-only deployment* * *1-layer Dense Urban (FR1/FR2) with SBFD-only deployment and dynamic/flexible TDD deployment* * *Urban Macro (FR1) with SBFD-only deployment and dynamic/flexible TDD-only deployment* * *Note: down-selection/prioritization of non-coexistence applicable scenarios can be done in Rel-18*   *Proposal 3: For the coexistence applicable scenario of static TDD and a new duplex operation, RAN1 takes the following applicable scenarios as a baseline*   * *1-layer/2-layer Dense Urban (FR1/FR2) with coexistence deployment of static TDD and SBFD or dynamic/flexible TDD.*    + *For 1-layer, 1 gNB or 7 gNBs with capability of SBFD or dynamic/flexible TDD are surrounded by gNBs with static TDD*   + *For 2-layer, Macro layer is for static TDD and Micro/indoor hotspot layer is for SBFD or dynamic/flexible TDD or Macro layer is for SBFD and Micro/indoor hotspot layer is for static TDD* * *Note: down-selection/prioritization of the coexistence applicable scenario of static TDD and a new duplex operation can be done in Rel-18*   *Proposal 4: For the coexistence applicable scenario of two new duplex operations, RAN1 takes the following applicable scenarios as a baseline*   * *2-layer Dense Urban (FR1/FR2) with coexistence deployment of SBFD and dynamic/flexible TDD deployment* * *For 2-layer, Macro layer is for SBFD and Micro/indoor hotspot layer is for dynamic/flexible TDD* * *Note: down-selection/prioritization of the coexistence applicable scenario of two new duplex operations can be done in Rel-18*   *Proposal 5: For evaluation purpose, RAN1 to prioritize the aligned subband configuration for SBFD operation.*  *Proposal 6: To evaluate impacts on adjacent channel, consider the followings as a baseline*   * *For Macro layer (in Urban macro or Dense urban),*    + *Two operators’ gNBs are located at the same (0% grid shift)*   + *The second operator’s gNBs are located at edge of the first operator’s gNB (100% grid shift)* * *FFS: indoor hotspot deployment* * *Adjacent channel uses static TDD operation.* |
| OPPO | ***Observation 1:*** *Subband non-overlapping full duplex at the gNB side is beneficial for macro cell and small cell. For macro cell, semi-static (from gNB perspective) subband non-overlapping full duplex can be sufficient; for small cell, dynamic (from gNB perspective) subband non-overlapping full duplex is more suitable to handle dynamic uplink-downlink traffic ratio.*  ***Proposal 1:*** *The deployment assumptions for Macro and InH in TR 38.828 can be used as reference.* |
| SHARP Corporation | ***Proposal 1:*** *RAN1 further studies duplex evolutions at least with the following scenarios*   * *Macro-cell scenario* * *Small-cell scenario*   ***Proposal 2****: RAN1 further studies scenarios where one TRP serves DL resource and another TRP serves UL resource for duplex evolution.* |
| InterDigital, Inc. | ***Observation 1.*** *Scenarios on subband non-overlapping (as for inter-subband CLI), subband partial overlapping and subband overlapping (as for intra-subband CLI) may achieve different gains based on at least traffic and/or cell sizes.*  ***Proposal 1.*** *Consider evaluating achieved gain and performance in subband non-overlapping scenario based on inter-subband CLI, and also in subband partial overlapping and subband overlapping scenarios based on intra-subband CLI.*  ***Proposal 2.*** *Consider evaluating intra- and inter-subband CLI in both FR1 and FR2 frequency ranges.*  ***Proposal 3.*** *Urban macro and indoor scenarios can be considered for evaluations in this study, and the indoor scenarios should be prioritized which have the most significant UE-to-UE CLI effects.* |
| Ericsson | *Proposal 8: Scenarios where SBFD performance improvements may be realistically possible and can be simulated/evaluated by participating entities should be prioritized.*  *Proposal 9: Regarding evaluations, both FR1 and FR2 should be considered in the study.*  *Proposal 12: Regarding evaluation scenarios, two-operator urban macro scenario should be considered as the baseline scenario. We do not preclude other scenarios but it is important to study at least one real-world deployment.*  *Proposal 14: For multi operator scenarios, it is important to consider realistic grid shifts. This should also include lower grid shifts. 0% grid shift (co-sited operators) should also be considered with proper channel model assumed between the gNBs of different operators that may be deployed at different heights. Consider studying 0%, 10% and 100% grid shifts.*  *Proposal 23: RAN1 to agree the system level simulation parameters listed in Annex B.* |
| KT Corp. | ***Observation 2:*** *No performance degradation was observed for Macro-to-Indoor and Indoor-to-Macro scenario*  ***Proposal 1:*** *For the deployment scenario, prioritize indoor small cell based gNB for sub-band full duplex gNB* |
| Panasonic | ***Proposal 1:*** *The following assumptions can be considered for link-level simulation.*   * *Scenarios used for coverage enhancement evaluation can be a starting point.* * *Typical subband allocation can be that edges of a band are for DL and the center of a band is for UL.* * *For DL evaluation, CLI due to time difference between DL and UL symbols needs to be taken into account if DL and UL are assumed as in-band.* |
| Apple | ***Proposal 1****: Full-duplex operation shall not be supported for macro-to-macro scenarios, at least for FR1.*  ***Observation1:*** *For indoor scenario, UL Tx power has a big impact (positive or negative) on the UE-to-UE CLI.* |
| NTT DOCOMO, INC. | ***Proposal 1:*** *Rural and Urban scenarios for FR1, and Indoor and Urban scenarios for FR2 is considered for evaluation.*  ***Proposal 2:*** *Evaluation assumptions is derived by both UL heavy traffic scenario (e.g. eMBB), and coverage enhancement scenario (e.g. VoIP).* |
| Nokia, Nokia Shanghai Bell | ***Proposal 3:*** *For evaluating the performance and identifying enhancements for SBFD, focus on co-channel scenarios with same UL-DL PRB partitioning in all the cells and on adjacent channel scenario with legacy TDD.*  ***Proposal 4:*** *For evaluating the performance and identifying enhancements for full duplex on non-overlapping PRBs, focus on the following scenarios for system-level simulations:*   * *Urban Macro or Dense urban macro, with focus on co-channel and adjacent channel coexistence.* * *Indoor small cell deployments, e.g. open office scenario from TR 38.901 or Indoor scenario from TR 38.828, or outdoor small cell deployment, e.g. by only considering the small-cell layer of HetNet Scenario 2A from TR 36.872. Small cell deployment evaluations shall focus on co-channel interference aspects.* |
| LG Electronics | ***Proposal 1:*** *For deployment scenarios of study on NR duplex evolution, deployment scenarios (i.e., Dense urban, Urban macro, and Indoor hotspot) which were applied for flexible duplex evaluation in Rel-14 NR SI are considered.*  Proposal 2: Evaluation for NR duplex evolution is performed at FR1 and FR2-1. Also, it can be discussed whether or not to consider FR 2-2 for study of NR duplex evolution. |
| MediaTek Inc. | ***Observation 5:*** *The feasibility and the performance of SBFD and DTDD schemes highly depend on the deployment scenarios considered for these schemes.*  ***Proposal 4:*** *For the evaluations of SBFD and DTDD schemes, RAN1 should consider the deployment scenarios listed in Table 1 and Table 2.*  ***Proposal 6:*** *For deployment scenarios with two operators, as starting point, 0% and 100% grid shift are assumed between the two operators’ gNBs:*   * *For the 100% grid shift in Macro deployment, gNBs of the second operator are shifted, relative to the gNBs’ locations of the first operator, by ±ISD/2 on one axis and ±ISD/(2\*sqrt(3)) on the other axis.*   Table 1: Deployment scenarios and topologies for SBFD.   |  |  |  | | --- | --- | --- | | Scenario No. | Deployment Scenario | Topology | | 1 | Single-operator SBFD  Same SBFD pattern in all cells | Single Layer: Urban, Dens Urban, Indoor | | 2 | Single-operator SBFD  Different SBFD patterns among cells | Single Layer: Urban, Dens Urban  HetNet: Macro-Indoor | | 3 | Two operators:  1st operator SBFD  2nd operator legacy TDD | Single Layer: Urban, Dens Urban, Indoor  HetNet: Macro-Indoor  Grid shift: 0% and 100% | |
| CEWiT | ***Proposal 1****: Sub-band partitioning for DL and UL resources based on fixed DL to UL ratio is supported for evaluations.* |
| Intel Corporation | ***Proposal 1:*** *For the evaluations of both NOFD, and dynamic/flexible TDD,*   * *For FR-1, both indoor office and urban macro scenario could be considered:* * *For FR-2, in addition to indoor office and urban macro scenario, the dense urban scenario could be considered.*   ***Proposal 5****:For system-level evaluations on NOFD*   * *Simulation assumptions, including deployment scenarios, antenna configurations, and related assumptions, as agreed during Rel-16 CLI/RIM, can be considered as starting points for system-level evaluations for NOFD operation.* * *Consider Table 3-7 in the Appendix II for NOFD evaluations in FR1 and FR2.* * *Non-full buffer with FTP traffic model 3 should be considered for traffic modelling.* * *DL/UL UPT should be used as the primary performance metric for SLS evaluations.*   ***Proposal 6:*** *RAN1 should consider appropriate NOFD configurations and modelling options for self- and cross-link interference for the evaluations for NOFD.*   * *Send an LS to RAN4 during RAN1 #109-e to receive inputs from RAN4 on self- and cross-link interference for NOFD operation.* |
| Qualcomm Incorporated | ***Observation 1:*** *Deployment scenarios that could benefit from subband full duplex, e.g. reduced latency and improve coverage, should be considered as baseline deployment scenarios. Other deployment scenarios may be considered as optional deployment scenarios.*  ***Observation 2:*** *Subband full duplex deployment for Massive MIMO macro cell deployment with large EIRP could benefit from UL coverage gain and latency improvement and at same time is challenging deployment due to large self-interference at gNB. For FR1, UMa with 500m ISD shall be considered and for FR2, UMa with 200m ISD shall be considered.*  ***Observation 3:*** *Subband full duplex deployment Indoor deployment may reduce requirements on gNB for self-interference mitigation due to small Tx Power. However, at least for FR1, it may be challenging deployment for handling cross link-interference.*  ***Observation 4:*** *Same UL/DL subband configurations across all cells is more practical from deployment scenario.*  ***Proposal 1:*** *For FR1, support UMa with 500m ISD as baseline deployment scenario for subband non-overlapping full duplex evaluation.*  ***Proposal 2:*** *For FR1, support UMi and InH as optional deployment scenarios.*  ***Proposal 3:*** *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 4:*** *For FR2, support UMi with 100m ISD for FR2-1, InH for FR2-2 and IAB as optional deployment scenarios.*  ***Proposal 5:*** *For FR1 and FR2, support configuration of same UL/DL subbands across cells for subband full duplex study for baseline evaluation.*  ***Proposal 6:*** *Support SLS as main tool for the evaluation of subband full duplex study.*  ***Proposal 7:*** *For subband full duplex deployment scenario, legacy TDD deployment scenario should be used as base for the evaluation.*  ***Proposal 12:*** *Support the following slot format configurations for the evaluation of subband full duplex.*   * *For subband full duplex deployment scenario, use same full duplex slot format XXXXX (X=FD=D+U).*   + *Note: all slots are flexible from the UE perspective.* * *For legacy TDD deployment scenario, use DDDSU as defined in Table A.1-2 of 38.838.*   ***Proposal 20:*** *RAN 1 shall consider simulation parameters in Tables 1, and 2 for FR1 full duplex evaluation.*  ***Proposal 21:*** *RAN 1 shall consider simulation parameters in Tables 1, 3, and 4 for FR2 full duplex evaluation.* |

## Summary

The deployment cases for SBFD proposed by companies are summarized as below:

* Deployment Case 1 (Non-coexistence case with single SBFD subband configuration): One single operator using one single carrier is considered. All the cells belonging to the operator use SBFD operation with the same SBFD subband configuration.
  + *CMCC, Huawei, ZTE, CATT, vivo, xiaomi, Samsung, Nokia, MediaTek, Qualcomm, New H3C*
* Deployment Case 2 (Non-coexistence case with multiple SBFD subband configurations): One single operator using one single carrier is considered. All the cells belonging to the operator use SBFD operation, but different cells may use different SBFD subband configurations.
  + *vivo, MediaTek, New H3C, ZTE (2nd priority)*
* Deployment Case 3 (Co-channel co-existence case): One single operator using one single carrier is considered. Among the cells belonging to the operator, some of them use legacy TDD operation while the others use SBFD operation with the same SBFD subband configuration.
  + *CMCC, ZTE, CATT, xiaomi, Samsung (medium priority), Huawei (2nd priority)*
* Deployment Case 4 (Adjacent-channel co-existence case): Two operators each using one carrier are considered and the two carriers are adjacent carriers. One operator uses legacy TDD operation while the other operator uses SBFD operation with the same SBFD subband configuration.
  + *ZTE, vivo, Ericsson, Nokia, MediaTek, Samsung (medium priority), Huawei (2nd priority)*

In addition, two companies [CATT, CMCC] propose that the performance evaluation for Deployment Case 4 can be done in RAN4.

Moderator suggests **Initial proposal 1-1 and 1-2.**

The applicable deployment scenarios for SBFD proposed by companies are summarized as below:

* Indoor hotspots or factory (low level of DL Tx power)
  + *CMCC (FR1, FR2), Huawei (FR1), ZTE (FR1), Spreadtrum, CATT, vivo, xiaomi, Samsung (FR1, FR2), OPPO, [SHARP], InterDigital (FR1, FR2), KT, Apple, DOCOMO (FR2), Nokia, LG (FR1, FR2-1), MediaTek, Intel (FR1, FR2), Qualcomm (FR2, 2nd priority for FR1)*
* Urban Macro (high level of DL Tx power)
  + *CMCC (FR1), Huawei (FR1, FR2), ZTE (FR1), Spreadtrum, CATT, vivo, xiaomi, Samsung (FR1), OPPO, SHARP, InterDigital (FR1, FR2), [DOCOMO], Nokia, Ericsson (FR1, FR2), LG (FR1, FR2-1), MediaTek, Intel (FR1, FR2), Qualcomm (FR1, FR2)*
* Dense Urban (medium level of Tx power)
  + Two layers: Macro + Micro
    - *ZTE (FR1), [xiaomi], [DOCOMO], [Nokia], [LG (FR1, FR2-1)], [Intel (FR2)], Samsung (2nd priority)*
  + Single layer: Macro layer or Micro layer
    - *CMCC (Micro layer, FR1, FR2), CATT, vivo, [xiaomi], Samsung (FR1, FR2), [DOCOMO], [Nokia], [LG (FR1, FR2-1)], MediaTek, Intel (FR2)*
* HetNet (Urban Macro + Indoor hotspot)
  + *MediaTek, ZTE (2nd priority), Samsung (2nd priority), Spreadtrum (2nd priority)*
* Urban Micro (medium level of Tx power)
  + *Qualcomm (2nd priority for FR1 and FR2-1), CMCC (FR1, FR2)*
* Rural
  + *DOCOMO (FR1)*
* IAB
  + *Qualcomm (2nd priority for FR2-2)*
* Isolated scenario
  + *ZTE (2nd priority), Spreadtrum (2nd priority)*

The number of combinations of the above deployment cases and scenarios will be large, especially considering both FR1 and FR2 need to be considered for some scenarios, some companies propose to prioritize some of the combinations to reduce the simulation workload.

Moderator suggests **Initial proposal 1-3 and 1-4.**

## 1st Round Proposals

### ***Initial proposal 1-1:***

For discussion purpose, define the following deployment cases for SBFD:

* Deployment Case 1 (Non-coexistence case with single SBFD subband configuration): One single operator using one single carrier is considered. All the cells belonging to the operator use SBFD operation with the same SBFD subband configuration.
* Deployment Case 2 (Non-coexistence case with multiple SBFD subband configurations): One single operator using one single carrier is considered. All the cells belonging to the operator use SBFD operation, but different cells may use different SBFD subband configurations.
* Deployment Case 3 (Co-channel co-existence case): One single operator using one single carrier is considered. Among the cells belonging to the operator, some of them use legacy TDD operation while the others use SBFD operation with the same SBFD subband configuration.
* Deployment Case 4 (Adjacent-channel co-existence case): Two operators each using one carrier are considered and the two carriers are adjacent carriers. One operator uses legacy TDD operation while the other operator uses SBFD operation with the same SBFD subband configuration.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Support the deployment scenario classification. Deployment Case 2 should be deprioritized or studied at later stage as it is more challenging for handling intra-SB cross-link interference. |
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### ***Initial proposal 1-2:***

For SBFD evaluation, take Deployment Case 1 and Case 4 as high priority, and take Deployment Case 2 as low priority.

* FFS: the priority of Deployment Case 3.
* FFS: Deployment Case 4 should be evaluated in RAN1-only, or RAN4-only, or both RAN1 and RAN4.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Support in principles. We think a phased approach for the study should be considered where Case 1 should highest priority and studied first as baseline. Then, case 4 should be studied as second step. Agree to deprioritize case 2. |
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### ***Initial proposal 1-3:***

For SBFD Deployment Case 1, at least consider the following scenarios for evaluation:

* For FR1,
  + Indoor hotspot (use Indoor hotspot defined in TR38.802 as starting point)
  + Urban macro (use Urban macro defined in TR38.802 as starting point)
  + Select one from {Dense Urban Macro layer, Dense Urban Micro layer, Urban Micro}
    - FFS which one
    - use Dense Urban defined in TR38.802 as starting point for Dense Urban Macro layer and Dense Urban Micro layer
    - use UMi in section 6.2 of TR38.901 or 3D-Umi in section 6 of TR36.873 as the starting point for Urban Micro
  + FFS: Rural
* For FR2-1,
  + Indoor hotspot (use Indoor hotspot defined in TR38.802 as starting point)
  + Select one from {Dense Urban Macro layer, Dense Urban Micro layer, Urban Micro}
    - FFS which one
    - use Dense Urban defined in TR38.802 as starting point for Dense Urban Macro layer and Dense Urban Micro layer
    - use UMi in section 6.2 of TR38.901 or 3D-UMi in section 6 of TR36.873 as the starting point for Urban Micro
  + FFS: IAB
* FFS: Whether FR2-2 is considered or not in Rel-18.

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| QC | For FR1, the first two scenarios (Urban Macro and Indoor hotspot) are sufficient for the evaluation. Urban Macro should be considered as the baseline deployment scenario as most of the SBFD benefits of UL coverage gain and latency reduction can be leveraged in Macro deployment.  For FR2, support InH and Dense Urban Macro (200m ISD) as baseline evaluation. We also support UMi (100m ISD) as additional evaluation. Additionally, it is important to consider the evaluation for InH for FR2-2. |
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### ***Initial proposal 1-4:***

For SBFD Deployment Case 4 (if evaluation is needed in RAN1), at least consider the following scenarios for evaluation:

* Urban Macro
* FFS: the grid shift between two networks
* FFS: Indoor hotspot, Dense Urban

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Support. |
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# Issue#2: Deployment scenarios for dynamic/flexible TDD

## Background and submitted proposal

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| **Company** | **Proposals** |
| CMCC | ***Proposal 2:*** *Focus on the following scenario for dynamic/flexible TDD evaluation:*   * *HetNet scenario with Urban Macro using DL dominated fixed TDD frame structure and Indoor hotspot using UL dominated fixed TDD frame structure in FR1*   + *FFS: whether flexible TDD can be additionally considered for indoor hotspot*   ***Proposal 27:*** *For dynamic/flexible TDD evaluation, consider channel model as following:*   * *TRxP-UE*   + *Macro-UE: UMa*   + *InH TRxP-UE: InH-Open Office* * *TRxP-TRxP:.*   + *Macro-Macro: UMa (hUE =25m)*   + *InH TRxP- InH TRxP: InH-Open Office (hUE =3m)*   + *Macro-InH TRxP: UMa (with O2I penetration loss and hUE =3m)* * *UE-UE:*   + *If the two UEs are in the same Indoor open office: follow Scenario A1 in Table 9 in section 5.1.2.*   + *Otherwise: follow Scenario A3 in Table 9 in section 5.1.2.*   ***Proposal 28:*** *For dynamic/flexible TDD evaluation, consider TDD configuration as following:*   * *Macro: DL heavy TDD UL/DL configuration, e.g., DDDSU, S (10DL : 2GP: 2UL)* * *Indoor: UL heavy TDD UL/DL configuration*   + *Mandatory: Fixed TDD UL/DL configuration, e.g., DSUUU, S (10DL : 2GP : 2UL)*   + *Optional: Dynamic TDD UL/DL configuration based on variable UL/DL traffic ratio*   ***Proposal 29:*** *For dynamic/flexible TDD evaluation, at least include DL/UL UPT (5%, 50%, 95%, Average) as performance metric.* |
| Huawei | ***Proposal 1:*** *To choose the deployment scenarios for Rel-18 NR duplex evolution, the industrial interest is an important factor that should be taken into account.*  ***Proposal 2****: Scenario 2-1 should be studied with a high priority for dynamic/flexible TDD enhancement.*   * *Scenario 2-1: Macro with DL dominant TDD configuration and Pico with UL dominant TDD configuration at local area (FR1 only).* |
| ZTE | ***Proposal 2****: Perform thorough analysis and study for dynamic/flexible TDD with the same priority as sub-band non-overlapping duplex.*  ***Proposal 4****: RAN1 studies at least the following scenarios in Rel-18 duplex SI*   * *For subband full duplex: urban macro, dense urban, indoor hotspot and urban macro + indoor hotspot (optional).* * *For dynamic/flexible TDD: dense urban, and urban macro + indoor hotspot*   ***Proposal 5****: RAN1 studies the following potential deployment for dynamic TDD and subband full duplex.*   * ***Deployment#1 (1st priority)****: Dynamic TDD, all the gNBs are legacy TDD gNB in the same channel with two different TDD slot formats.* * ***Deployment#2 (1st priority)****: Subband full duplex, all the gNBs are subband full duplex gNB in the same channel with the same time/frequency pattern without any co-existence co-channel or adjacent channel interference.* * ***Deployment#3 (1st priority)****: Subband full duplex, all the gNBs in channel#1 are subband full duplex gNB with the same time/frequency pattern. There are also other legacy TDD gNBs in adjacent channel#2.* * ***Deployment#4 (1st priority)****: Subband full duplex, some gNBs in channel#1 are subband full duplex gNB with the same time/frequency pattern. There are also other legacy TDD gNBs in channel#1.* * ***Deployment#5 (2nd priority)****: Subband full duplex, gNBs in channel#1 are subband full duplex gNB with the different time/frequency patterns.* * ***Deployment#6 (2nd priority)****: Isolated case. There is only one single subband full duplex gNB without any interference from other co-channel or adjacent channel gNBs.*   ***Proposal 10****: For system level simulation for subband full duplex and dynamic TDD,*   * *DL and UL need to be simulated simultaneously in the same system* * *Performance metrics: Cell capacity (i.e., average number of supported users per cell)* * *Traffic model: XR or FTP3*   ***Proposal 13****: For Subband full duplex and dynamic TDD simulation,*   * *Perform geometry calibration for subband full duplex at least for Urban macro, Indoor hotspot, Dense urban and urban macro + indoor hotspot (optional).* * *Perform geometry calibration for dynamic TDD at least for Dense urban and urban macro + indoor hotspot.* * *Consider the ACLR/ACIR model defined in TR38.828 for geometry calibration.* * *Consider two different self-interference capabilities for gNB, i.e., 90dB and 130dB.*   ***Proposal 14****: Consider the simulation parameters in table 7-1 in Appendix for geometry calibration.* |
| CATT | ***Proposal 2:*** *The deployment scenarios for flexible/dynamic TDD evaluation include indoor hotspot and heterogeneous deployment with macro and indoor.*  ***Proposal 3:*** *System-level evaluation is used for Rel-18 SBFD and flexible/dynamic TDD evaluation.*  ***Proposal 16:*** *Performance of flexible/dynamic TDD with existing CLI handling schemes is the baseline to show potential performance gain of new CLI handling schemes.*  ***Proposal 17:*** *Adopt simulation assumptions in Table 2 for flexible/dynamic TDD system evaluation.* |
| vivo | *Proposal 1: For SBFD and dynamic TDD evaluation, system-level simulation assumptions in TR 38.828 can be used as a starting point.*  *Proposal 2: For non-coexistence* *scenarios in SBFD or dynamic TDD evaluation, UMa, 1-layer DU and InH can be high priority.*  *Proposal 3: 100% grid-shifted deployment of gNB can be used for multiple operators’ co-existence scenarios.*  *Proposal 4: For co-coexistence scenarios in SBFD or dynamic TDD evaluation, UMa, 1-layer DU and InH, can be considered.* |
| xiaomi | ***Proposal 3:*** *For flexible/dynamic TDD, evaluate and study the performance in HetNet scenario.* |
| Samsung | *Proposal 1: For evaluation purpose, the following three categories of applicable scenarios can be evaluated with their priorities.*   * *The non-coexistence applicable scenario with highest priority* * *The coexistence applicable scenario of static TDD and a new duplex operation with medium priority* * *The coexistence applicable scenario of two new duplex operations with low priority*   *Proposal 2: For non-coexistence applicable scenario, RAN1 takes the following applicable scenarios as a baseline*   * *Indoor hotspot (FR1/FR2) with SBFD-only deployment and dynamic/flexible TDD-only deployment* * *1-layer Dense Urban (FR1/FR2) with SBFD-only deployment and dynamic/flexible TDD deployment* * *Urban Macro (FR1) with SBFD-only deployment and dynamic/flexible TDD-only deployment* * *Note: down-selection/prioritization of non-coexistence applicable scenarios can be done in Rel-18*   *Proposal 3: For the coexistence applicable scenario of static TDD and a new duplex operation, RAN1 takes the following applicable scenarios as a baseline*   * *1-layer/2-layer Dense Urban (FR1/FR2) with coexistence deployment of static TDD and SBFD or dynamic/flexible TDD.*    + *For 1-layer, 1 gNB or 7 gNBs with capability of SBFD or dynamic/flexible TDD are surrounded by gNBs with static TDD*   + *For 2-layer, Macro layer is for static TDD and Micro/indoor hotspot layer is for SBFD or dynamic/flexible TDD or Macro layer is for SBFD and Micro/indoor hotspot layer is for static TDD* * *Note: down-selection/prioritization of the coexistence applicable scenario of static TDD and a new duplex operation can be done in Rel-18*   *Proposal 4: For the coexistence applicable scenario of two new duplex operations, RAN1 takes the following applicable scenarios as a baseline*   * *2-layer Dense Urban (FR1/FR2) with coexistence deployment of SBFD and dynamic/flexible TDD deployment* * *For 2-layer, Macro layer is for SBFD and Micro/indoor hotspot layer is for dynamic/flexible TDD* * *Note: down-selection/prioritization of the coexistence applicable scenario of two new duplex operations can be done in Rel-18*   *Proposal 5: For evaluation purpose, RAN1 to prioritize the aligned subband configuration for SBFD operation.*  *Proposal 6: To evaluate impacts on adjacent channel, consider the followings as a baseline*   * *For Macro layer (in Urban macro or Dense urban),*    + *Two operators’ gNBs are located at the same (0% grid shift)*   + *The second operator’s gNBs are located at edge of the first operator’s gNB (100% grid shift)* * *FFS: indoor hotspot deployment* * *Adjacent channel uses static TDD operation.* |
| Nokia, Nokia Shanghai Bell | ***Proposal 1:*** *The dynamic TDD study should focus on identifying enhancements and solutions that allow gNBs to more freely adjust their TDD radio frame configuration in line with their traffic demands by combating cross-link interference.*  ***Proposal 2:*** *For evaluating the performance and identifying enhancements for dynamic TDD operation, focus on a two-layer HetNet scenarios with outdoor macro cells + outdoor or indoor small cells with cochannel deployment (e.g. based on Scenario 1 from TR 36.872).*   * *Macro layer uses static DL-heavy TDD radio frame configuration (to ensure inter-operator coexistence) while the small cell layer operates with dynamic TDD in line with their UL and DL traffic demands.*   ***Proposal 8:*** *For the traffic models and KPIs for dynamic TDD evaluations, assume the following:*   * *FTP3 traffic model with large payload size, e.g. 0.5 MBytes.*    + *Main KPI: User perceived throughput (UPT).*   + *Offered load selected to meet a certain resource utilization (RU) target, e.g. 10% (low load) and 40% (medium load).*   + *Both DL-heavy traffic, 4:1, and symmetric 1:1 DL:UL traffic can be considered.*   *For the proposed HetNet scenario with dynamic TDD, it may be further considered to have DL-heavy traffic for the UEs connected to the macro-cells, while the small-cell UEs have balanced or UL-heavy traffic.* |
| LG Electronics | ***Proposal 1:*** *For deployment scenarios of study on NR duplex evolution, deployment scenarios (i.e., Dense urban, Urban macro, and Indoor hotspot) which were applied for flexible duplex evaluation in Rel-14 NR SI are considered.*  Proposal 2: Evaluation for NR duplex evolution is performed at FR1 and FR2-1. Also, it can be discussed whether or not to consider FR 2-2 for study of NR duplex evolution. |
| MediaTek | ***Observation 5:*** *The feasibility and the performance of SBFD and DTDD schemes highly depend on the deployment scenarios considered for these schemes.*  ***Proposal 4:*** *For the evaluations of SBFD and DTDD schemes, RAN1 should consider the deployment scenarios listed in Table 1 and Table 2.*  ***Proposal 6:*** *For deployment scenarios with two operators, as starting point, 0% and 100% grid shift are assumed between the two operators’ gNBs:*   * *For the 100% grid shift in Macro deployment, gNBs of the second operator are shifted, relative to the gNBs’ locations of the first operator, by ±ISD/2 on one axis and ±ISD/(2\*sqrt(3)) on the other axis.*   Table 2: Deployment scenarios and topologies for DTDD.   |  |  |  |  | | --- | --- | --- | --- | | Scenario No. | Operator#1 | Operator#2 | Notes | | 1 | Macro | Macro | Grid shift: 0%, 100% | | 2 | HetNet: Macro-Small | Macro | Macro cells: aligned TDD pattern  Indoor cells: misaligned with Macro cells | | 3 | Indoor | Indoor | Misaligned TDD patterns,  Grid shift: between 0% and 100% | |
| Intel Corporation | ***Proposal 1:*** *For the evaluations of both NOFD, and dynamic/flexible TDD,*   * *For FR-1, both indoor office and urban macro scenario could be considered:* * *For FR-2, in addition to indoor office and urban macro scenario, the dense urban scenario could be considered.*   ***Proposal 7****: For system-level evaluations on dynamic/flexible TDD*   * *Simulation assumptions, including deployment scenarios, antenna configurations, and related assumptions, summarized in Table 3-7 in the Appendix II can be considered as starting points for system-level evaluations for dynamic/flexible TDD operation in FR1 and FR2.* * *Non-full buffer with FTP traffic model 3 should be used for traffic modelling.* * *DL/UL UPT should be used as the primary performance metric.* * *Specific dynamic/flexible TDD configuration choices could be reported by companies.* |
| Qualcomm Incorporated | ***Proposal 22:*** *For FR1, support the following deployment scenarios for study on potential enhancement on Dynamic/flexible TDD.*   * *Baseline: UMa.* * *Optional: HetNet (Macro and Pico)*   ***Proposal 23:*** *For FR2, support the following deployment scenarios for study on potential enhancement on Dynamic/flexible TDD.*   * *Baseline: UMa (FR2-1) macro and InH (FR2-1)* * *Optional: UMi (FR2-1) and InH (FR2-2)*   ***Proposal 24:*** *Support SLS as main tool for the evaluation of potential enhancement of dynamic/flexible TDD study.*  ***Proposal 25:*** *For dynamic/flexible TDD,*   * *Utilize the BS antenna configuration of legacy baseline TDD* * *Slot format is all flexible FFFFF (D or U direction is picked based on traffic)*   ***Proposal 26:*** *All other simulation assumptions dynamic/flexible TDD evaluation can be the same as legacy TDD, e.g. antenna configuration could be the same as legacy TDD with single panel configuration for Tx or Rx. For FR2, the bandwidth configuration dynamic/flexible TDD evaluation could be either all for DL or all for UL.* |

## Summary

In Rel-14 NR SI, flexible TDD has been evaluated for indoor hotspot, urban macro and dense urban scenarios. Some companies suggest to take these deployment scenarios as a starting point, but some other companies suggest to avoid the repetition work that has been done before, and to focus on HetNet scenario with outdoor Macro cells and indoor small cells deployed in the same carrier which has not been studied sufficiently yet. The interested scenarios from companies are summarized as below:

* HetNet (Urban Macro + Indoor hotspot):
  + *CMCC (FR1), Huawei (FR1), ZTE, CATT, xiaomi, Samsung (FR1, FR2), Nokia, [MediaTek], Qualcomm (2nd priority for FR1)*
* Dense Urban:
  + *ZTE, vivo (1-layer), Samsung (FR1, FR2), Nokia, LG, [MediaTek], Intel (FR2)*
* Indoor hotspot:
  + *vivo, Samsung (FR1, FR2), LG, MediaTek, Intel (FR1, FR2), Qualcomm (FR2-1)*
* Urban Macro:
  + *vivo, Samsung (FR1), LG, MediaTek, Intel (FR1, FR2), Qualcomm (FR1, FR2-1)*
* Urban Micro:
  + *Qualcomm (2nd priority for FR2-1)*

For dynamic/flexible TDD evaluation in HetNet (Urban Macro + Indoor hotspot) or Dense urban with two layers, the following TDD configurations are proposed:

* Macro using DL dominant static TDD and small cell using UL dominant static TDD
  + *CMCC, ZTE, Huawei*
* Macro using DL dominant static TDD and small cell using dynamic TDD
  + *Samsung, Nokia*

Moderator suggests **Initial proposal 2-1.**

Regarding adjacent-channel coexistence between two operators with legacy TDD operation and dynamic TDD operation, it has been evaluated in Rel-16 CLI WI, some companies [Nokia, CMCC] suggest to avoid repeating such evaluation in Rel-18, while some other companies [Samsung] show interest in it. Moderator suggests **Initial question 2-2**.

## 1st Round Proposals

### ***Initial proposal 2-1:***

For evaluation of dynamic/flexible TDD deployed by one single operator, at least consider the following scenarios for evaluation for FR1 and FR2:

* HetNet with Urban Macro and Indoor hotspot deployed in the same carrier:
  + Macro gNBs use DL dominant static TDD UL/DL configuration (e.g., DDDSU, S (10DL: 2GP: 2UL)), and Indoor gNBs use UL dominant static TDD UL/DL configuration (e.g., DSUUU, S (10DL: 2GP: 2UL))
    - (Optional) Indoor gNBs use dynamic TDD UL/DL configuration
* Dense Urban with two layers deployed in the same carrier:
  + Macro gNBs use DL dominant static TDD UL/DL configuration (e.g., DDDSU), and Micro gNBs use UL dominant static TDD UL/DL configuration (e.g., DSUUU)
    - (Optional) Micro gNBs use dynamic TDD UL/DL configuration
* FFS: Indoor hotspot, Urban Macro

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Don’t support. Urban Macro should be considered as baseline scenario for evaluation of dynamic TDD. It is surprising that both InH and Urban Macro listed as FFS while it has same support level as Dense urban! |
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### ***Initial question 2-2:***

Whether the adjacent-channel coexistence case between dynamic TDD and legacy TDD defined as below needs to be considered for evaluation or not?

* Adjacent-channel co-existence between dynamic TDD and legacy TDD: Two operators each using one carrier are considered and the two carriers are adjacent carriers. One operator uses legacy TDD operation while the other operator uses dynamic TDD operation.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Don’t support the study of coex between dynamic and legacy TDD. This means repeating of earlier R16 work on coexistence. What should be considered is the coexistence between SBFD and legacy TDD (Case 4). |
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# Issue #3: Interference modeling and LS to RAN4

## Background and submitted proposals

* **Interference modeling**

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| **Company** | **Proposals** |
| CMCC | ***Observation 1:*** *There are self-interference (SI), co-channel inter-subband CLI (including co-channel inter-cell gNB-gNB inter-subband CLI and co-channel intra-cell/inter-cell UE-UE inter-subband CLI), co-channel intra-subband CLI (including co-channel inter-cell gNB-gNB intra-subband CLI and co-channel inter-cell UE-UE intra-subband CLI), and adjacent-channel CLI (including adjacent-channel gNB-gNB CLI and adjacent-channel UE-UE CLI) in SBFD network.*  ***Proposal 5:*** *At least for RAN1’s discussion and evaluation for SBFD, define the following interference types:*   * *Self-interference (SI) at gNB side: Interference caused by DL transmission in DL subband in a SBFD carrier to UL reception in UL subband in the same carrier at the gNB side.* * *Co-channel inter-cell gNB-gNB inter-subband CLI: CLI caused by DL transmission of the aggressor gNB in DL subband in a SBFD carrier to UL reception of the victim gNB in UL subband (different from the DL subband) in the same SBFD carrier.* * *Co-channel intra-cell/inter-cell UE-UE inter-subband CLI: CLI caused by UL transmission of the aggressor UE in UL subband in a SBFD carrier to DL reception of the victim UE in DL subband (different from the UL subband) in the same cell or neighbouring cell in the same SBFD carrier.* * *Co-channel inter-cell gNB-gNB intra-subband CLI: CLI caused by DL transmission of the aggressor gNB in a subband in one carrier to UL reception of the victim gNB in the same subband in the same carrier.* * *Co-channel inter-cell UE-UE intra-subband CLI: CLI caused by UL transmission of the aggressor UE in a subband in one carrier to DL reception of the victim UE in the same subband in the same carrier.* * *Adjacent-channel gNB-gNB CLI: CLI caused by DL transmission of the aggressor gNB in a legacy TDD carrier to UL reception of the victim gNB in another adjacent SBFD carrier.* * *Adjacent-channel UE-UE CLI: CLI caused by UL transmission of the aggressor UE in a SBFD carrier to DL reception of the victim UE in another adjacent legacy TDD carrier.*   ***Proposal 6:*** *At least for RAN1’s discussion and evaluation for SBFD, consider the following for interference modelling:*   * *Self-interference ratio (SIR):* *The ratio of the power transmitted by gNB on one frequency unit (e.g., one subband/RB/subcarrier) in a SBFD carrier to the total interference received by the same gNB on a different frequency unit (e.g., another subband/RB/subcarrier) in the same SBFD carrier.*   + *The SIR can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit.*   + *For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-SIR, , denoting the ratio of the power transmitted by gNB on subcarrier m to the interference received by the same gNB on a subcarrier n.* * *Inter-subband interference ratio (ISIR): The ratio of the power transmitted by the aggressor gNB/UE on one frequency unit (e.g., one subband/RB/subcarrier) in a SBFD carrier to the total interference received by the victim gNB/UE on a different frequency unit (e.g., another subband/RB/subcarrier) in the same SBFD carrier.*   + *Note: The ISIR can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit.*   + *For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-ISIR, , denoting the ratio of the power transmitted by the aggressor gNB/UE on subcarrier m to the interference received by the victim gNB/UE on a subcarrier n.* * *Adjacent-channel interference ratio (ACIR): RAN1 understands the ACIR in TR38.828 is defined as the ratio of the power transmitted by the aggressor gNB/UE on one carrier to the total interference received by the victim gNB/UE on the adjacent carrier, i.e., the ACIR in TR38.828 is described per carrier.*    + *For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of ACIR with finer granularity, e.g., the per-subcarrier-ACIR, , denoting the ratio of the power transmitted by the aggressor gNB/UE on subcarrier m in one carrier to the interference received by the victim gNB/UE on another subcarrier n in the adjacent carrier.*   ***Proposal 8:*** *Take the values of interference ratios in Table 5 as the assumption for RAN1 calibration for SBFD evaluation.*  Table 5 RAN1 assumptions on interference ratios for Phase-1 calibration   |  |  |  | | --- | --- | --- | |  | **FR1** | **FR2** | | Scaling factor | dB(273 \* 12) for 100MHz channel bandwidth with 30kHz SCS | dB(264\*12) for 200MHz channel bandwidth with 60kHz SCS | | gNB’s per-subcarrier-SIR: | Option 1: 138 dB  Option 2: 163 dB | Option 1: 117 dB  Option 2: 142 dB | | gNB-gNB per-subcarrier-ISIR: | 78 dB | 57 dB | | UE-UE per-subcarrier-ISIR: | 63 dB | 51 dB | | gNB-gNB per-subcarrier-ACIR: | 78 dB | 57 dB | | UE-UE per-subcarrier-ACIR: | 63 dB | 51 dB | |
| Huawei | ***Observation 4:*** *The cross link interference can be classified as linear and non-linear interference, where downlink signals from own cell or other cells may lead to blocking, and BS-to-BS CLI, UE-to-UE CLI, and BS self CLI have impact on demodulation performance.*  ***Proposal 6:*** *The following interferences will impact the system performance and should be studied in Rel-18 NR duplex evolution:*   * *Linear interference*   + *In-band BS-to-BS CLI*   + *In-band UE-to-UE CLI*   + *Blocking caused by DL/UL signal* * *Non-linear interference*   + *Inter-subband BS-to-BS CLI*   + *Inter-subband UE-to-UE CLI*   + *Inter-subband BS self CLI*   ***Proposal 7****: The interference models of in-band BS-to-BS CLI and in-band UE-to-UE CLI used in TR 38.802 can be reused for Rel-18 NR duplex evolution.*  ***Proposal 8****: The following aspects for non-linear interference modeling should be studied in Rel-18 NR duplex evolution:*   * *Strength of non-linear interference (RAN4)* * *Correlation of non-linear interference between antenna ports*   + *Non-linear interference can be modeled as uncorrelated signals*   + *Non-linear signal on each transmit antenna port can be modeled as Gaussian distribution, i.e., beamforming should not be considered in the modeling of non-linear interference* * *Channel for non-linear interference*   + *Both large fading and fast fading should be modeled* |
| ZTE | ***Proposal 7****: Align understanding on the following terminologies.*   * ***Co-channel interference****: The interference is from carrier#1 to carrier#2, where the centre frequency of carrier#1 from aggressor and carrier#2 from victim is the same.* * ***Adjacent channel interference****: The interference is from carrier#1 to carrier#2, where the centre frequency of carrier#1 from aggressor and carrier#2 from victim is different.* * ***Subband****: A subband is a number of continuous RBs within a BWP, including DL subband and UL subband.* * ***Intra-subband interference****: The interference is from subband#1 to subband#2, where frequency range of subband#1 from aggressor and subband#2 from victim is the same.* * ***Inter-subband interference****: The interference is from subband#1 to subband#2, where frequency range of subband#1 from aggressor and subband#2 from victim is different.* * ***Co-channel intra-subband interference****: The interference is from subband#1 of carrier#1 to subband#2 of carrier#2, where frequency range of subband#1 from aggressor and subband#2 from victim is the same and the centre frequency of carrier#1 and carrier#2 is the same.* * ***Co-channel inter-subband interference****: The interference is from subband#1 of carrier#1 to subband#2 of carrier#2, where frequency range of subband#1 from aggressor and subband#2 from victim is different and the centre frequency of carrier#1 and carrier#2 is the same.*   ***Proposal 8****: Consider the following 9 interferences in RAN1 simulation. Among them, gNB self-interference (I1), gNB-gNB co-channel inter-subband interference (I3) and UE-UE co-channel inter-subband interference (I6) need RAN4 input.*   * *gNB self-interference (I1): RAN4 input is needed.* * *gNB-gNB co-channel intra-subband interference (I2)* * *gNB-gNB co-channel inter-subband interference (I3): RAN4 input is needed.* * *gNB-gNB adjacent interference (I4)* * *UE-UE co-channel intra-subband interference (I5)* * *UE-UE co-channel inter-subband interference (I6): RAN4 input is needed.* * *UE-UE adjacent-channel interference (I7)* * *gNB-UE co-channel intra-subband interference (DL) (I8)* * *UE-gNB co-chanel intra-subband interference (UL) (I10)*   ***Proposal 9****: Use the following interference model for subband full duplex simulation.*   * *gNB self-interference per RB. Basic assumption for RAN1 simulation calibration: 90dB and 130dB.*      * *gNB-gNB co-channel intra-subband interference per RB of this intra-subband per aggressor gNB*      * *gNB-gNB co-channel inter-subband interference per RB per inter-subband per aggressor gNB*      * *gNB-gNB adjacent interference per RB per aggressor gNB*      * *UE-UE co-channel intra-subband interference per RB of this intra-subband per aggressor UE*      * *UE-UE co-channel inter-subband interference per RB per inter-subband per aggressor UE*      * *UE-UE adjacent interference per RB per aggressor UE*      * *gNB-UE co-channel intra-subband interference (DL) per RB of this intra-subband per aggressor gNB*      * *UE-gNB co-chanel intra-subband interference (UL) per RB of this intra-subband per aggressor UE* |
| CATT | ***Proposal 4****: Self-interference power for SBFD evaluation is modeled according to the following equation:*   * *Pself-interference = BS Tx power + BS antenna gain – X*   + *Value of X is FFS subject to RAN4’s inputs*   ***Proposal 5:*** *For SBFD evaluation, prioritize the case that subband configuration across all the cells operating SBFD is the same.*  ***Proposal 6:*** *Inter-sector inter-subband CLI power and inter-gNB inter-subband CLI power are modeled according to the following equations respectively:*   * *Pinter-sector inter-SB CLI = aggressor sector Tx power + aggressor sector Tx antenna gain + victim sector Rx antenna gain– Y1* * *Pinter-gNB inter-SB CLI = aggressor gNB Tx power + aggressor gNB Tx antenna gain + victim gNB Rx antenna gain– PL – Y2*   + *Values of Y1 and Y2 are FFS subject to RAN4’s inputs*   ***Proposal 7:*** *UE-to-UE inter-subband CLI power is modeled according to the following equation:*   * *Pinter UE inter-SB CLI = aggressor UE Tx power + aggressor UE Tx antenna gain + victim UE Rx antenna gain– PL – Z*   + *Value of Z is FFS subject to RAN4’s inputs* |
| vivo | *Observation 1: New interference types e.g., self-interference and inter-subband CLI are introduced in full duplex operation, which may have impacts on the system performance.*  *Proposal 10: Modeling of the interference types highlighted by yellow color in Table 3 should be investigated for SBFD evaluation.*  Table 3 interference types for full duplex operation   |  |  |  |  | | --- | --- | --- | --- | | **Index** | **Aggressor/victim** | **Channel/subband** | **Details** | | ① | UE-to-BS | Co-channel intra-subband or Adjacent-channel | UL-to-UL interference, legacy | | ② | BS-to-UE | Co-channel intra-subband or Adjacent-channel | DL-to-DL interference, legacy | | ③ | BS-to-BS | Co-channel inter-subband | Self-interference | | ④ | BS-to-BS | Co-channel inter-subband or Adjacent-channel | Inter-cell CLI | | ⑤ | BS-to-BS | Co-channel intra-subband | Inter-cell CLI | | ⑥ | UE-to-UE | Co-channel inter-subband | Intra-cell CLI | | ⑦ | UE-to-UE | Co-channel inter-subband or Adjacent-channel | Inter-cell CLI | | ⑧ | UE-to-UE | Co-channel intra-subband | Inter-cell CLI | |
| xiaomi | ***Proposal 9:*** *Self-interference can be modeled by the following formula and the capability on self-interference suppression is up to RAN4.* |
| Samsung | *Proposal 12: To model the received power of gNB-to-gNB (DL-to-UL) interference at subcarrier k from all aggressor gNBs (), RAN1 takes the following model as a starting point.*   * *where DL Transmission power at subcarrier j of aggressor gNB effective channel gain between the aggressor gNB and victim gNB .*    + *The suppression value should be asked to RAN4*   + *RAN1 further to study the simplified model for the suppression level and its feasibility should be asked to RAN4*   *Proposal 13: To model the residual self-interference power after self-interference cancelation at subcarrier k (), the representative value for is considered as additional noise level in addition to the original noise level.*   * *The (worst-case) residual self-interference value should be asked to RAN4*   *Proposal 14: To model the received power of UE-to-UE (UL-to-DL) interference at subcarrier k from all aggressor UEs (), RAN1 takes the following model as a starting point.*   * *where UL Transmission power at subcarrier j of aggressor UE effective channel gain between the aggressor UE and victim UE .*    + *The suppression value should be asked to RAN4*   + *RAN1 further to study the simplified model for the suppression level and its feasibility should be asked to RAN4* |
| OPPO | ***Proposal 3:*** *The following interference types should be considered in the evaluation:*   * *gNB->gNB* * *gNB->UE* * *UE->UE* * *UE->gNB*   ***Proposal 4:*** *ACIR listed in TR 38.828 could be reused for adjacent carriers, if needed.*  ***Proposal 5:*** *Send LS to RAN4 to ask whether and how to model the interference ratio among subbands.* |
| Ericsson | *Proposal 1: Adopt a net effect model that captures the essential behaviours of a realistic DPD and PA combination with -45 dBc ACLR compliance. This requires input from RAN4.*  *Proposal 2: Adopt a simple crest factor processing model, e.g., hard clipping, that captures the essential behaviours of a BS design to increase transmit power. This requires input from RAN4.*    *Proposal 3: The self-interference channel should be modeled as a set of tapped delay lines directly from TX sub-array ports to RX sub-array ports.*  *Proposal 4: Self-interference channel coefficients should be based on realistic setups supported by real measurements or high-fidelity electromagnetic (EM) evaluations.*    Figure 10: Illustration of self-interference channel modeling for panels with sub-arrays  *Proposal 5: The gNB receiver in an SBFD system needs to be carefully studied and modelled with respect to various aspects such as selectivity, linearity etc.*  *Proposal 6: Considering there is no RAN4 requirement on inter-subband selectivity within the channel bandwidth, RAN1/4 needs to study whether the rejection of UL signal in the UL part of an SBFD carrier by a UE receiving DL signal in the DL part is the same as adjacent channel selecitivity requirement.*  *Proposal 7: Send an LS to RAN4 requesting feedback on various radio and antenna modelling aspects that are required for RAN1 to establish evaluation assumptions for both system-level and link-level simulations.*  *Proposal 11: RAN1 to agree on net effect relative PSD interference metrics for system level evaluations taking into account both transmitter and receiver. In general, different values are needed for different interference cases.* |
| Nokia | Observation 4: On the evaluation methodology for full duplex on non-overlapping PRBs, the selected scenarios should focus on the impacts of the full-duplex-specific sources of interference, namely:   * *(intra-cell) gNB self-interference from in-band emissions* * *(inter-cell) gNB-to-gNB interference from in-band emissions* * *(intra-cell and inter-cell) UE-to-UE interference from in-band emissions* * *(inter-cell) gNB-to-gNB interference from adjacent-channel emissions* * *(inter-cell) UE-to-UE interference from adjacent-channel emissions*   Proposal 3: For evaluating the performance and identifying enhancements for SBFD, focus on co-channel scenarios with same UL-DL PRB partitioning in all the cells and on adjacent channel scenario with legacy TDD.  ***Proposal 5:*** *For the modelling of in-band emissions (IBE) for SBFD evaluations, adopt the UE IBE model as specified 3GPP TS 38.101-1, Section 6.4.2.3 including General, IQ Image and Carrier leakage components.*  ***Proposal 6:*** *RAN1 and RAN4 to discuss and agree on models for gNB and UE ICS and gNB IBE.*  ***Proposal 7****: For the modelling of inter-subband co-channel interference in SBFD:*   * *IBE and ICS models are used to determine an inter-subband interference ratio (ISIR) in dB which determines the interference generated by an allocated (i.e. ‘aggressor’) PRB or resource element (RE) to a non-allocated (‘victim’) PRB/RE, relative to the normalized aggressor’s transmit power.* * *For gNB self-interference calculations, assume a self-interference suppression value α (in dB) expressing the gNB’s capability to suppress inter-subband interference (determined from ISIR) using a combination of Tx-Rx isolation and analog or digital cancellation.*   + *Simulation can be run with different values of α, e.g. from 50 dB (conservative) to 110 dB (highly-optimistic).* * *For gNB-gNB or UE-UE links, the resulting co-channel inter-subband interference is only a function of the aggressor’s transmit power, ISIR and coupling gain between the aggressor and victim gNB or UE. No additional interference suppression is considered.* |
| LG | ***Proposal 3:***  *Apply Adjacent Subband Interference Ratio (ASIR) from BS to BS and from UE to UE for evaluation of subband non-overlapped full duplex. Discuss on exact values of ASIR for evaluation.*  ***Proposal 4:*** *Apply residual Self-Interference (SI) after self-interference cancelation or mitigation for evaluation of subband non-overlapped full duplex. Discuss on definition and exact values of residual SI.* |
| MediaTek | ***Observation 1:*** *A model that is similar to in-channel selectivity need to be considered for the impact of inter-UE CLI on reception performance in the scenario when UE channel BWs/BWPs overlap across sub-bands. This model is within RAN4 expertise.*  ***Observation 2:*** *The characteristics/requirements relating to Tx & Rx channel selectivity are within RAN4 expertise.*  ***Observation 3:*** *Different RAN4 RF requirements exist for the different potential UE configuration approaches, and the different requirements may have different impacts on the ability of legacy UEs to be protected from interference in a SBFD operating scenario.*  ***Observation 4:*** *RAN1 making “assumptions” on how these requirements should be characterized in the context of SBFD does not seem appropriate.*  ***Proposal 2:*** *RAN1 to liaise RAN4 to request feedback on the characterization of the relevant UE Tx/Rx requirements for the different UE configuration scenarios: 1) UE channel BWs/BWPs overlap across sub-bands, 2) UE channel BW/BWP confined within a sub-band.*  ***Proposal 9:*** *For DTDD and SBFD evaluations, RAN1 considers the following interference types:*   * *At the gNB: Inter-gNB, adjacent channel CLI, Inter-gNB co-channel CLI, Inter-gNB intra-subband CLI, Inter-gNB inter-subband CLI, and Self-interference.* * *At the UE: Inter-UE adjacent channel CLI, Inter-UE co-channel CLI, Inter-UE intra-subband CLI, Inter-UE inter-subband CLI.* |
| CEWiT | ***Proposal 7:*** *Define the SI model to be used for SBFD evaluations.* |
| Qualcomm | **Self-interference modelling**  ***Observation 9:*** *The amount of residual self-interference depends on gNB spatial isolation, subband frequency isolation, digital interference cancellation and beamform nulling/isolation.*  ***Proposal 15:*** *The residual self-interference at gNB receiver is modelled as fixed value across the UL subband and is given by*   * *where is the overall self-inference reduction capability of the gNB by means of spatial isolation, subband frequency isolation, digital interference cancellation and beamform nulling/isolation.* * *FFS: Frequency selective residual self-interference modelling.*   Clutter reflection  ***Observation 10:*** *There is no 3GPP model for clutter modelling.*  ***Observation 11:***  *Exact clutter modelling is complicated and may drain RAN1 time and efforts.*  ***Observation 12:*** *A statistical clutter model based on statistics of clutter strength and AoA is simple model.*  ***Proposal 16:*** *At least for FR2, for subband full duplex deployment scenario, simplified statistical clutter modelling can be considered based on statistics of cluster power and AoA.*  ***Proposal 17:*** *For subband full duplex deployment scenario, simplified statistical clutter modelling shall be intra-serving-gNB model and shall have no impact on other gNBs and UEs in the network.*  Cross-link interference modelling (inter-gNB and inter-UE)  ***Observation 13:*** *RAN1 needs to agree on the inter-subband cross-link interference model for subband full duplex evaluation.*  ***Proposal 18:*** *Inter-gNB inter-subband CLI can be modelled using two steps*   * *Step 1: gNB-to-gNB channel model based on TR 38.802 / 38.901 as gNB-to-UE channel and height adjustment.* * *Step 2: inter-SB leakage based on the frequency isolation between DL subband and UL subband.*   ***Proposal 19:*** *Inter-UE inter-subband CLI can be modelled using two steps*   * *Step 1: UE-to-UE channel model based on TR 38.802 / 38.901.* * *Step 2: inter-SB leakage based on the frequency isolation between UL subband and DL subband.* |

* **LS to RAN4**

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 7:*** *Include the following in the LS to RAN4:*   * *RAN1 would like to ask RAN4 about the values or value ranges of the following interference ratios used for SBFD evaluation.*   1. *gNB’s self-interference ratio (SIR)*      + *In RAN1’s understanding, SIR is defined as the ratio of the power transmitted by gNB on one frequency unit (e.g., one subband/RB/subcarrier) in a SBFD carrier to the total interference received by the same gNB on a different frequency unit (e.g., another subband/RB/subcarrier) in the same SBFD carrier.*      + *Note: It is up to RAN4 to describe the SIR per subband, per RB, or per subcarrier. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-SIR.*   2. *Inter-subband interference ratio (ISIR) including gNB-gNB ISIR and UE-UE ISIR*      + *In RAN1’s understanding, ISIR is defined as the ratio of the power transmitted by the aggressor gNB/UE on one frequency unit (e.g., one subband/RB/subcarrier) in a SBFD carrier to the total interference received by the victim gNB/UE on a different frequency unit (e.g., another subband/RB/subcarrier) in the same SBFD carrier.*      + *Note: It is up to RAN4 to describe the ISIR per subband, per RB, or per subcarrier. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-ISIR.*   3. *Adjacent-channel interference ratio (ACIR) including gNB-gNB ACIR and UE-UE ACIR*      + *RAN1 understands the ACIR in TR38.828 is the ratio of the power transmitted by the aggressor gNB/UE on one carrier to the total interference received by the victim gNB/UE on the adjacent carrier, i.e., the ACIR in TR38.828 is described per carrier.*      + *For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of ACIR with finer granularity, e.g., the per-subcarrier-ACIR defined as the ratio of the power transmitted by the aggressor gNB/UE on one subcarrier in one carrier to the interference received by the victim gNB/UE on another subcarrier in the adjacent carrier.* * *If values or value ranges of SIR/ISIR/ACIR provided by RAN4 are defined with a coarser granularity, e.g., per carrier/subband/RB, it is preferred that a method can be provided by RAN4 to derive the SIR/ISIR/ACIR values with finer granularity from the SIR/ISIR/ACIR values with coarser granularity.* * *Note: At least for RAN1’s simulation purpose, the typical value of the bandwidth of the UL subband in subband non-overlapping full duplex is tens of MHz, e.g., 20MHz, 40MHz, 60MHz, etc…* * *Note: It’s up to RAN4 to consider the antenna/RF and algorithm design, which include antenna isolation, TX IM suppression in the RX part, filtering and digital interference suppression. From RAN1 perspective, it is preferred that the SIR value under the assumption of separate-Tx/Rx antenna architecture can be provided by RAN4 as well as the corresponding separate-Tx/Rx antenna configuration including the placement of the Tx antennas and Rx antennas in the horizontal/vertical domain.* |
| ZTE | ***Proposal 6****: To progress RAN1 study on duplex smoothly,*   * *RAN1 starts identifying information that requires RAN4 input and sends LS to RAN4 as soon as possible.* * *RAN1 firstly calibrates geometry based on some simplified interference model defined by RAN1 and secondly calibrates geometry based on RAN4’s input once it is available.* |
| xiaomi | ***Proposal 8****: Send an LS to RAN4 to check the views on the following two issue:*   * *How to model the inter-subband interference from a DL subband to a UL subband?* * *How to model the inter-subband interference from a UL subband to a UL subband?* |
| OPPO | ***Proposal 5:*** *Send LS to RAN4 to ask whether and how to model the interference ratio among subbands.* |
| Ericsson | *Proposal 1: Send an LS to RAN4 requesting feedback on various radio and antenna modelling aspects that are required for RAN1 to establish evaluation assumptions for both system-level and link-level simulations.*  *Proposal 2: In the LS to RAN request feedback on the following gNB and UE aspects:*   * *gNB*   + *Realistic net effect model that captures the essential behavior of a realistic DPD and PA combination with -45 dBc ACLR compliance.*   + *Simple model of creset factor reduction (CFR) processing, e.g., hard clipping with filtering, that captures the essential behaviors of a practical BS designed for PA efficiency and ACLR compliance.*   + *Realistic models on UL receiver selectivity, dynamic range and nonlinearity behaviors*   + *Realistic antenna aspects including*     - *Self-interference isolation levels between each Tx sub-array port and each Rx sub-array port including*       * *Frequency dependence*       * *Any dependence on beam direction*     - *Any impact on Tx or Rx beam patterns due to the antenna isolation design*     - *Isolation levels between sectors within the same site for the same operator*     - *Isolation levels between co-sited multi-sector antennas for different operators*   + *Any other important modelling components characterizing typical gNB TX/RX functions.* * *UE*   + *Realistic model for determining the inter-subband emission levels within the channel bandwidth and the emission levels in adjacent channels*   + *Considering there is no RAN4 requirement on inter-subband selectivity within the channel bandwidth, feedback is needed on what rejection level of UL signal in the UL part of an SBFD carrier by a UE receiving DL signal in the DL part can be used* |
| MediaTek | ***Proposal 1:*** *RAN1 to work on the assumption that full SLS will be performed by RAN1 for SBFD, but dependent on information from RAN4 to characterise CLI modelling at UE Tx and Rx. Confirm the way of working between RAN1 and RAN4 with a SID revision at RAN#96.*  ***Proposal 3:*** *Include the above questions in the liaison to RAN4.*   1. *Please can RAN4 provide input to enable RAN1 to characterize CLI (Cross-Link Interference) between UEs in system-level simulations for the following UE operating scenarios for FR1 and FR2:*    1. *UE Channel BW and BWP in DL or UL is not confined within a sub-band for SBFD operation.*    2. *UE channel BW and BWP in DL and UL are confined within a sub-band for SBFD operation.*   *Note: RAN4 should take into account that interference may vary across slots, and that Tx and Rx between UEs in different sub-bands may not be fully time-aligned.*   1. *Does RAN4 see any RAN4 specific pros and cons with either configuration a or b?* |
| Intel | ***Proposal 6:*** *RAN1 should consider appropriate NOFD configurations and modelling options for self- and cross-link interference for the evaluations for NOFD.*   * *Send an LS to RAN4 during RAN1 #109-e to receive inputs from RAN4 on self- and cross-link interference for NOFD operation.* |

## Summary

Several companies [CMCC, Huawei, ZTE, CATT, vivo, Samsung, OPPO, Nokia, MediaTek, Qualcomm, etc.] raise that SBFD suffer from multiple types of interference including linear interferences and non-linear interferences, e.g.,

* gNB self-interference (SI): Non-linear interference
* gNB-UE co-channel intra-subband interference
* UE-gNB co-channel intra-subband interference
* (inter-cell) gNB-gNB co-channel intra-subband CLI
* (inter-cell) UE-UE co-channel intra-subband CLI
* (inter-cell) gNB-gNB co-channel inter-subband CLI: Non-linear interference
* (intra-cell/inter-cell) UE-UE co-channel inter-subband CLI: Non-linear interference
* gNB-gNB Adjacent-channel CLI: Non-linear interference
* UE-UE Adjacent-channel CLI: Non-linear interference

Moderator thinks it is important for companies to have a common understanding on the terminologies used to describe these interferences firstly, so moderator suggests **Initial proposal 3-1** and **Initial proposal 3-2.**

Regarding these interferences, several companies propose different or similar modelling methods for gNB self-interference, gNB-gNB or UE-UE co-channel inter-subband CLI, and gNB-gNB or UE-UE adjacent-channel CLI. Some companies propose to define the following interference ratios which need RAN4’s input for interference modelling:

* Self-interference ratio (SIR): It is used to represent the overall self-interference suppression capability of gNB by means of spatial isolation, subband frequency isolation, digital interference cancellation and beamform nulling/isolation, etc. The SIR, denoted as , can be defined as the ratio of the power transmitted by gNB on a frequency unit *m* (e.g., subband/RB/subcarrier *m*) in a SBFD carrier to the residual self-interference received by the same gNB on a different frequency unit *n* (e.g., another subband/RB/subcarrier *n*) in the same SBFD carrier.
* Inter-subband interference ratio (ISIR): denoted as or , it can be defined as the ratio of the power transmitted by the aggressor gNB/UE on a frequency unit *m* (e.g., subband/RB/subcarrier *m*) in a SBFD carrier to the interference received by the victim gNB/UE on a different frequency unit *n* (e.g., another subband/RB/subcarrier *n*) in the same SBFD carrier.
* Adjacent-channel interference ratio (ACIR): The ACIR in TR38.828 is defined as the ratio of the power transmitted by the aggressor gNB/UE on one carrier to the total interference received by the victim gNB/UE on the adjacent carrier, i.e., the ACIR in TR38.828 is described per carrier. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of ACIR with finer granularity, e.g., the per-subcarrier-ACIR, or , denoting the ratio of the power transmitted by the aggressor gNB/UE on subcarrier *m* in one carrier to the interference received by the victim gNB/UE on another subcarrier *n* in the adjacent carrier.



(a) gNB per sub-carrier-SIR

 

(b) gNB-gNB per-subcarrier-ISIR (c) UE-UE per-subcarrier-ISIR

 

(d) gNB-gNB per-subcarrier-ACIR (e) UE-UE per-subcarrier-ACIR

Regarding interference modelling, moderator suggests **Initial proposal 3-3, Initial proposal 3-4 and Initial proposal 3-5.**

Several companies [Ericsson, CMCC, ZTE, xiaomi, OPPO, Intel, etc.] suggest to send an LS to RAN4 regarding the interference modelling as soon as possible.

CMCC suggests to include the following in the LS to RAN4:

* RAN1 would like to ask RAN4 about the values or value ranges of the following interference ratios used for SBFD evaluation.

1. gNB’s self-interference ratio (SIR)
   * + In RAN1’s understanding, SIR is defined as the ratio of the power transmitted by gNB on one frequency unit (e.g., one subband/RB/subcarrier) in a SBFD carrier to the total interference received by the same gNB on a different frequency unit (e.g., another subband/RB/subcarrier) in the same SBFD carrier.
     + Note: It is up to RAN4 to describe the SIR per subband, per RB, or per subcarrier. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-SIR.
2. Inter-subband interference ratio (ISIR) including gNB-gNB ISIR and UE-UE ISIR
   * + In RAN1’s understanding, ISIR is defined as the ratio of the power transmitted by the aggressor gNB/UE on one frequency unit (e.g., one subband/RB/subcarrier) in a SBFD carrier to the total interference received by the victim gNB/UE on a different frequency unit (e.g., another subband/RB/subcarrier) in the same SBFD carrier.
     + Note: It is up to RAN4 to describe the ISIR per subband, per RB, or per subcarrier. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-ISIR.
3. Adjacent-channel interference ratio (ACIR) including gNB-gNB ACIR and UE-UE ACIR
   * + RAN1 understands the ACIR in TR38.828 is the ratio of the power transmitted by the aggressor gNB/UE on one carrier to the total interference received by the victim gNB/UE on the adjacent carrier, i.e., the ACIR in TR38.828 is described per carrier.
     + For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of ACIR with finer granularity, e.g., the per-subcarrier-ACIR defined as the ratio of the power transmitted by the aggressor gNB/UE on one subcarrier in one carrier to the interference received by the victim gNB/UE on another subcarrier in the adjacent carrier.

* If values or value ranges of SIR/ISIR/ACIR provided by RAN4 are defined with a coarser granularity, e.g., per carrier/subband/RB, it is preferred that a method can be provided by RAN4 to derive the SIR/ISIR/ACIR values with finer granularity from the SIR/ISIR/ACIR values with coarser granularity.
* Note: At least for RAN1’s simulation purpose, the typical value of the bandwidth of the UL subband in subband non-overlapping full duplex is tens of MHz, e.g., 20MHz, 40MHz, 60MHz, etc…
* Note: It’s up to RAN4 to consider the antenna/RF and algorithm design, which include antenna isolation, TX IM suppression in the RX part, filtering and digital interference suppression. From RAN1 perspective, it is preferred that the SIR value under the assumption of separate-Tx/Rx antenna architecture can be provided by RAN4 as well as the corresponding separate-Tx/Rx antenna configuration including the placement of the Tx antennas and Rx antennas in the horizontal/vertical domain.

Ericsson suggests to send an LS to RAN4 requesting feedback on various radio and antenna modelling aspects that are required for RAN1 to establish evaluation assumptions for both system-level and link-level simulations. In the LS to RAN4 request feedback on the following gNB and UE aspects:

* gNB
  + Realistic net effect model that captures the essential behavior of a realistic DPD and PA combination with -45 dBc ACLR compliance.
  + Simple model of creset factor reduction (CFR) processing, e.g., hard clipping with filtering, that captures the essential behaviors of a practical BS designed for PA efficiency and ACLR compliance.
  + Realistic models on UL receiver selectivity, dynamic range and nonlinearity behaviors
  + Realistic antenna aspects including
    - Self-interference isolation levels between each Tx sub-array port and each Rx sub-array port including
      * Frequency dependence
      * Any dependence on beam direction
    - Any impact on Tx or Rx beam patterns due to the antenna isolation design
    - Isolation levels between sectors within the same site for the same operator
    - Isolation levels between co-sited multi-sector antennas for different operators
  + Any other important modelling components characterizing typical gNB TX/RX functions.
* UE
  + Realistic model for determining the inter-subband emission levels within the channel bandwidth and the emission levels in adjacent channels
  + Considering there is no RAN4 requirement on inter-subband selectivity within the channel bandwidth, feedback is needed on what rejection level of UL signal in the UL part of an SBFD carrier by a UE receiving DL signal in the DL part can be used

MediaTek suggests to include the following questions in LS to RAN4:

* Please can RAN4 provide input to enable RAN1 to characterize CLI (Cross-Link Interference) between UEs in system-level simulations for the following UE operating scenarios for FR1 and FR2:
  + UE Channel BW and BWP in DL or UL is not confined within a sub-band for SBFD operation.
  + UE channel BW and BWP in DL and UL are confined within a sub-band for SBFD operation.
  + Note: RAN4 should take into account that interference may vary across slots, and that Tx and Rx between UEs in different sub-bands may not be fully time-aligned.
* Does RAN4 see any RAN4 specific pros and cons with either configuration

Regarding LS to RAN4, moderator suggest **Initial proposal 3-6** and **Initial question 3-7**.

## 1st Round Proposals

Based on the inputs from the contributions submitted to RAN1#109-e, some initials proposals are made as follows. Companies are encouraged to provide views on these proposals.

### ***Initial proposal 3-1:***

For discussion purpose, consider the following as RAN1’s common understanding:

* Co-channel interference: The interference is from the aggressor in carrier#1 to the victim in carrier#2, where the carrier#1 and carrier#2 are the same carrier.
  + Co-channel intra-subband interference: The interference is caused by transmission of the aggressor in subband#1 in a carrier to reception of the victim in subband#2 in the same carrier, where the frequency range of subband#1 and subband#2 are the same.
  + Co-channel inter-subband interference: The interference is caused by transmission of the aggressor in subband#1 in a carrier to reception of the victim in subband#2 in the same carrier, where the frequency range of subband#1 and subband#2 are different.
* Adjacent channel interference: The interference is from the aggressor in carrier#1 to the victim in carrier#2, where the carrier#1 and carrier#2 are adjacent carriers.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | It is bit confusing to use carrier#1 and carrier#2 and then mention they are same carrier. Similarly for the subband #1 and subband#2. Also, the use of ‘frequency range’ maybe miss-understood as FR1/FR2. Suggest the following:   |  | | --- | | For discussion purpose, consider the following as RAN1’s common understanding:   * Co-channel interference: The interference is from the aggressor ~~in carrier#1~~ to the victim in ~~carrier#2, where the carrier#1 and carrier#2 are~~ the same carrier.   + Co-channel intra-subband interference: The interference is caused by transmission of the aggressor in a subband ~~#1~~ in a carrier to reception of the victim in the same subband~~#2~~ in the same carrier~~, where the frequency range of subband#1 and subband#2 are the same~~.   + Co-channel inter-subband interference: The interference is caused by transmission of the aggressor in subband#1 in a carrier to reception of the victim in subband#2 in the same carrier, where the frequency range of subband#1 and subband#2 are different. * Adjacent channel interference: The interference is from the aggressor in carrier#1 to the victim in carrier#2, where the carrier#1 and carrier#2 are adjacent carriers. | |
|  |  |
|  |  |
|  |  |

### ***Initial proposal 3-2:***

Consider the following interference types in RAN1 SBFD simulation:

* gNB self-interference (SI): Interference caused by DL transmission in DL subband in a carrier to UL reception in UL subband in the same carrier at the gNB side, where the frequency range of the DL subband and the UL subband are different.
* gNB-UE co-channel intra-subband interference: This is the same as the legacy DL interference type in legacy TDD network with static TDD UL/DL configuration.
* UE-gNB co-channel intra-subband interference: This is the same as the legacy UL interference type in legacy TDD network with static TDD UL/DL configuration.
* (inter-cell) gNB-gNB co-channel intra-subband CLI: CLI caused by DL transmission of the aggressor gNB in a subband in one carrier to UL reception of the victim gNB in the same subband in the same carrier.
* (inter-cell) UE-UE co-channel intra-subband CLI: CLI caused by UL transmission of the aggressor UE in a subband in one carrier to DL reception of the victim UE in the same subband in the same carrier.
* (inter-cell) gNB-gNB co-channel inter-subband CLI: CLI caused by DL transmission of the aggressor gNB in DL subband in a carrier to UL reception of the victim gNB in UL subband in the same carrier, where the frequency range of the DL subband and the UL subband are different.
* (intra-cell/inter-cell) UE-UE co-channel inter-subband CLI: CLI caused by UL transmission of the aggressor UE in UL subband in a carrier to DL reception of the victim UE in DL subband in the same cell or neighboring cell in the same carrier, where the frequency range of the UL subband and the DL subband are different.
* gNB-gNB adjacent-channel CLI: CLI caused by DL transmission of the aggressor gNB in a carrier to UL reception of the victim gNB in another adjacent carrier.
* UE-UE adjacent-channel CLI: CLI caused by UL transmission of the aggressor UE in a carrier to DL reception of the victim UE in another adjacent carrier.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | We have few comments on the proposal:   * The use of ‘frequency range’ may be confusing. Instead, suggest the following wording, “where the DL subband and the UL subband are non-overlapping in frequency”. * Since the deployment scenarios with the same UL/DL subbands are prioritized, then we suggest to only consider SI, (inter-cell) gNB-gNB co-channel inter-subband CLI, and (intra-cell/inter-cell) UE-UE co-channel inter-subband CLI as highest priority in SBFD simulation. * Then, the gNB-gNB adjacent-channel CLI and UE-UE adjacent-channel CLI should be studied as second step for Case 4 coexistence study. * Support to deprioritize (inter-cell) gNB-gNB co-channel and (inter-cell) UE-UE co-channel intra-subband CLI. |
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### ***Initial proposal 3-3:***

For discussion of gNB self-interference modelling, consider introducing self-interference ratio (SIR) to represent the overall self-interference suppression capability of gNB by means of spatial isolation, subband frequency isolation, digital interference cancellation and beamform nulling/isolation, etc. The SIR, denoted as , can be defined as the ratio of the power transmitted by gNB on a frequency unit *m* (e.g., subband/RB/subcarrier *m*) in a SBFD carrier to the residual self-interference received by the same gNB on a different frequency unit *n* (e.g., another subband/RB/subcarrier *n*) in the same SBFD carrier.

* The value or value range of SIR should be asked to RAN4. The SIR can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-SIR.
  + FFS: details of gNB self-interference modelling, e.g., the gNB self-interference at UL subcarrier *n* can be modelled as
  + , wherein,
    - *m* is the DL subcarrier index.
    - is gNB’s DL transmission power at subcarrier *m* (in dBm).
    - is the per-subcarrier-SIR.
  + The feasibility of the gNB self-interference modelling should be asked to RAN4

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| QC | We have few comments on the proposal:   * + The description of self-interference should include the spatial description in addition to the frequency description. The SIR represents the ratio of the total transmit power by gNB across all transmit chains to the received power on single receive chain.   + For FR2, the spatial isolation could depend on the Tx and Rx beam-pair especially for the clutter reflections.   + There is no single value for the SIR as it depends on gNB implementation and the knobs it deploys to handle the SI. Also, this value range is different for FR1 and FR2. Preferred value is per-RB for SLS evaluation, not per RE   + In addition to the direct leakage, there could be reflection from nearby reflectors (clutter). Support to add an FFS to study clutter impact   Suggest the following:   |  | | --- | | For discussion of gNB self-interference modelling, consider introducing self-interference ratio (SIR) to represent the overall self-interference suppression capability of gNB by means of spatial isolation, subband frequency isolation, digital interference cancellation and beamform nulling/isolation, etc. The SIR, denoted as , can be defined as the ratio of the total power transmitted by gNB across all transmit chains on a frequency unit *m* (e.g., subband/RB/subcarrier *m*) in a SBFD carrier to the residual self-interference received by the same gNB on a single receiver chain on a different frequency unit *n* (e.g., another subband/RB/subcarrier *n*) in the same SBFD carrier.   * The ~~value or~~ value range of SIR should be asked to RAN4 for each frequency range. The SIR can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-RB-SIR.   + FFS: details of gNB self-interference modelling, e.g., the gNB self-interference at UL subcarrier *n* can be modelled as   + , wherein,     - *m* is the DL subcarrier index.     - is gNB’s total DL transmission power at subcarrier *m* (in dBm).     - is the per-RB-SIR.     - is gNBs self-interference received power at receiver chain i at subcarrier *n* (in dBm).   + FFS: the dependence of on Tx/Rx beam-pair for FR2 especially for clutter echo.   + FFS: consider a statistical clutter model based on statistics of clutter strength and AoA.   + The feasibility of the gNB self-interference modelling should be asked to RAN4 | |
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### ***Initial proposal 3-4:***

For discussion of gNB-gNB or UE-UE co-channel inter-subband CLI modelling, consider introducing gNB-gNB or UE-UE inter-subband interference ratio (ISIR), denoted as or , defined as the ratio of the power transmitted by the aggressor gNB/UE on a frequency unit *m* (e.g., subband/RB/subcarrier *m*) in a SBFD carrier to the interference received by the victim gNB/UE on a different frequency unit *n* (e.g., another subband/RB/subcarrier *n*) in the same SBFD carrier.

* The value or value range of ISIR should be asked to RAN4. The ISIR can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit. For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of per-subcarrier-ISIR.
* FFS: details of gNB-gNB co-channel inter-subband CLI modelling, e.g.,
  + The gNB-gNB co-channel inter-subband CLI from aggressor gNB to victim gNB *A* at UL subcarrier *n* can be modelled as *,* wherein,
    - *m* is the DL subcarrier index of aggressor gNB .
    - is the DL transmission power of aggressor gNB at subcarrier *m* (in dBm).
    - is the effective channel gain between the aggressor gNBand the victim gNB , taking into account the pathloss, penetration loss, shadow fading, Tx/Rx antenna gain, beamforming gain and fast fading.
    - is the gNB-gNB per-subcarrier-ISIR.
* FFS: details of UE-UE co-channel inter-subband CLI modelling, e.g.,
  + The UE-UE co-channel inter-subband CLI from aggressor UE to victim UE *B* at DL subcarrier *n* can be modelled as *, wherein,*
    - *m* is the UL subcarrier index of aggressor UE .
    - is the UL transmission power of aggressor UEat subcarrier *m* (in dBm)*.*
    - *is* the effective channel gain between the aggressor UEand the victim UE , taking into account the pathloss, penetration loss, shadow fading, Tx/Rx antenna gain, beamforming gain and fast fading.
    - is the UE-UE per-subcarrier-ISIR.
* FFS: Modelling of co-site inter-sector co-channel inter-subband CLI
* The feasibility of the gNB-gNB and UE-UE co-channel inter-subband CLI modelling should be asked to RAN4

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| QC | Support in principle. We have few comments on the proposal:   * + The value of the ISIR is different for FR1 and FR2.   + Preferred value is per-RB for system level evaluation.   + Channel model based on TR 38.802 and TR 38.901 with some adjustments on height and angular spread. |
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### ***Initial proposal 3-5:***

Regarding gNB-gNB or UE-UE adjacent-channel inter-subband CLI modelling, the ACIR in TR38.828 can be used as the starting point.

* RAN1 understands the ACIR in TR38.828 is defined as the ratio of the power transmitted by the aggressor gNB/UE on one carrier to the total interference received by the victim gNB/UE on the adjacent carrier, i.e., the ACIR in TR38.828 is described per carrier.
* For RAN1’s simulation purpose, it is preferred that RAN4 can provide the value or value range of ACIR with finer granularity, e.g., the per-subcarrier-ACIR, or , denoting the ratio of the power transmitted by the aggressor gNB/UE on subcarrier *m* in one carrier to the interference received by the victim gNB/UE on another subcarrier *n* in the adjacent carrier.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Support in principle, prefer value per RB value specified for each frequency range.  In addition, the BS-BS and UE-UE adjacent channel should be modelled following the description of TR 38.828. |
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### ***Initial proposal 3-6:***

RAN1 sends an LS to RAN4 to ask about the values or value ranges of the following interference ratios used for SBFD evaluation in RAN1:

* gNB self-interference ratio (SIR)
* Inter-subband interference ratio (ISIR) including gNB-gNB ISIR and UE-UE ISIR
* Adjacent-channel interference ratio (ACIR) including gNB-gNB ACIR and UE-UE ACIR
* FFS: other details of the LS

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Support in principle. |
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### ***Initial question 3-7:***

Whether RAN1 needs to additionally include the following or any other contents in LS to RAN4?

* gNB
  + Realistic net effect model that captures the essential behavior of a realistic DPD and PA combination with -45 dBc ACLR compliance.
  + Simple model of creset factor reduction (CFR) processing, e.g., hard clipping with filtering, that captures the essential behaviors of a practical BS designed for PA efficiency and ACLR compliance.
  + Realistic models on UL receiver selectivity, dynamic range and nonlinearity behaviors

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | For the SLS evaluation, no other input is needed from RAN4. If agreed to adopt LLS as addition evaluation methodology, some input from RAN4 may be needed for proper UE and gNB NL modelling. |
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# Issue #4: Other evaluation methodology and assumptions

## Issue #4-1: Performance metrics and high-level evaluation methodology

### Background and submitted proposal

* **Performance Metrics and Traffic Model**

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| **Company** | **Proposals** |
| CMCC | ***Proposal 23:*** *One or multiple of the following metrics can be used for Phase-1 calibration*   * *Metric 1: CDF of coupling loss (serving cell) from port 0* * *Metric 2: CDF of DL wideband SINR considering legacy gNB-UE interference only* * *Metric 3: CDF of SBFD DL SINR before receiver considering legacy gNB-UE interference and co-channel UE-UE inter-subband CLI* * *Metric 4: CDF of legacy UL SINR before receiver considering legacy UE-gNB interference only* * *Metric 5: CDF of SBFD UL SINR before receiver considering legacy UE-gNB interference, self-interference and co-channel gNB-gNB inter-subband CLI* * *FFS: definition of the above metrics* |
| ZTE | ***Proposal 6****: To progress RAN1 study on duplex smoothly,*   * *RAN1 starts identifying information that requires RAN4 input and sends LS to RAN4 as soon as possible.* * *RAN1 firstly calibrates geometry based on some simplified interference model defined by RAN1 and secondly calibrates geometry based on RAN4’s input once it is available.*   ***Proposal 10****: For system level simulation for subband full duplex and dynamic TDD,*   * *DL and UL need to be simulated simultaneously in the same system* * *Performance metrics: Cell capacity (i.e., average number of supported users per cell)* * *Traffic model: XR or FTP3* |
| Spreadtrum, BUPT | ***Proposal 2:*** *At least the following metrics should be considered for SBFD study:*   * *Geometry* * *Coverage* * *Delay* * *{5%,50%,95%,average} UPTs*   ***Proposal 3:*** *Simulation assumptions including baseline, SBFD configuration, FTP model and interference modeling are recommended to be calibrated ASAP.* |
| CATT | ***Proposal 10:*** *Adopt DL/UL UPT and user plane latency as performance metrics for SBFD evaluation.*  ***Proposal 11:*** *Adopt DL/UL UPT as performance metric for flexible/dynamic TDD evaluation.*  ***Proposal 14:*** *Consider low, medium and high RU ratios in SBFD system evaluation.*  ***Proposal 15:*** *Adopt simulation assumptions in Table 1 for SBFD system evaluation.* |
| Vivo | *Proposal 5: For NR duplex evolution, traffic configuration in Table 1 can be considered as the starting point.*  Table 1. Traffic configuration for evaluation of NR duplex enhancement   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Traffic model | Packet size | arrival rate λ | Traffic load | Ratio of DL/UL traffic | | FTP3 | 0.1Mbytes | Based on traffic load | Low:25%  Medium:50%  [high:80%, optional] | {2:1}  {4:1}  [{1:1}, optional] | | 0.5Mbytes | | 1.5Kbytes | 100p/s | -- | -- |   *Proposal 7: For fair comparison between semi-static SBFD and semi-static TDD, the DL-to-UL resource ratio is assumed to be the same.*  *Proposal 9: The following performance metrics can be considered for NR duplex evolution,*   * *Latency (mean, 5, 50, 95 %)* * *User-perceived throughput (mean, 5, 50, 95 %)* * *Resource utilization*   + *RU =* * *CDF of received SINR* |
| xiaomi | ***Proposal 6:*** *At least the following metrics should be considered for performance evaluation:*   * *UL/DL UPT* * *Latency of uplink packet transmission* |
| Samsung | *Proposal 7: For evaluation, RAN1 takes DL/UL UPT CDF and Latency CDF as a performance metric to draw a conclusion and recommendation in TR.*   * *DL/UL received SINR can be used for calibration* * *FFS: other performance metrics*   ***Proposal 8:*** *For evaluation purpose, RAN1 takes the deployment related parameters in Tables 2-4 as a starting point.* |
| OPPO | ***Proposal 6:*** *KPIs should be clarified to analyze the evaluation, preferably including statistics (including distribution etc) of SINR, throughput, spectrum effectiveness and CLI.* |
| Ericsson | *Proposal 16: In system level simulation, for the initial phase of performance evaluation comparison is performed between different duplex modes based on the same amount of input traffic within each networks.*  *Proposal 17: For co-existence evaluations (e.g. between two networks), in addition to the case of same input traffic in the two networks, also consider high input traffic in the aggressor and low in the victim.*  *Proposal 18: For traffic load in system level simulations, it is based on an aggregated system resource utilization between UL and DL denoted as , where r is the ratio of DL/UL resource allocation and u is the DL/UL resource utilization, i.e., the average ratio of used versus available resources in the respective direction.*  *Proposal 19: For performance metrics to be used in the system level simulations, the following are proposed:*   * *Resource utilization: Resource utilization per transmission direction* * *Coverage: Target Maximum Pathloss (MPL) to achieve a certain average bit rate (10Mbps for DL and 1Mbps for UL).* * *User Throughput: Mean user throughput and 5%ile user throughput*   Resource utilization per direction  *Proposal 20: RAN1 studies SBFD’s effects on DL and UL resource utilization per direction to provide better understanding of SBFD operations.*  Coverage  *Proposal 21: RAN1 studies SBFD’s effects on DL and UL coverage under different traffic loads / resource utilization levels to provide better understanding of SBFD operations.*  User Throughput  *Proposal 22: RAN1 studies SBFD’s effects on DL and UL mean and cell-edge user throughputs under different traffic loads and grid shifts to provide better understanding of SBFD operations.*  *Proposal 23: RAN1 to agree the system level simulation parameters listed in Annex B.* |
| LG | ***Proposal 8:*** *Discuss DL and UL packet size and packet arrival rate for evaluation of subband non-overlapping full duplex and dynamic/flexible TDD.*  ***Proposal 9:*** *Discuss whether DL and UL traffic is simultaneously generated for evaluation of subband non-overlapping full duplex and dynamic/flexible TDD.*  ***Proposal 11:*** *Average UE throughput and average UE latency can be adopted as the performance metric for evaluation for subband non-overlapping full duplex and dynamic/flexible TDD. Discuss further details of definition of average UE throughput and average UE latency.* |
| CEWiT | ***Proposal 2:*** *Baseline TDD system with same DL to UL ratio can be used as reference for comparing the performance of SBFD system.*  ***Proposal 3:*** *Define the various parameters (e.g., inter packet delay) for FTP 3 to be used in the evaluations.*  ***Proposal 4:*** *Define the use cases for SBFD evaluation, a. latency reduction, b. UL SINR improvement.*  ***Proposal 5:*** *The following evaluation metrics are supported:*   * *a. Average latency for DL and UL* * *b. Average SINR in UL*   ***Proposal 6:*** *Evaluation metric “latency” is defined as the time taken from the generation of a packet to the complete transmission of the packet (including HARQ transmission).* |
| Intel | ***Proposal 3:***   * *Simulation assumptions and evaluation methodologies as agreed during Rel-17 NR coverage enhancement SI can be considered as starting points for evaluation of coverage performance for NOFD operation.* * *Consider Table 1 and Table 2 in the Appendix I for NOFD performance evaluation for FR1 and FR2, respectively.* * *Self-interference modelling should be considered for link-level simulation for NOFD.*   ***Proposal 4:****For target reliability and packet size assumptions, User Plane (UP) latency for UL and DL may be evaluated using numerical analyses while using results from link- and system-level evaluations to determine details of UL/DL scheduling flows for PUSCH and PDSCH scheduling.*  ***Proposal 5:*** *For system-level evaluations on NOFD*   * *Simulation assumptions, including deployment scenarios, antenna configurations, and related assumptions, as agreed during Rel-16 CLI/RIM, can be considered as starting points for system-level evaluations for NOFD operation.*    + *Consider Table 3-7 in the Appendix II for NOFD evaluations in FR1 and FR2.* * *Non-full buffer with FTP traffic model 3 should be considered for traffic modelling.* * *DL/UL UPT should be used as the primary performance metric for SLS evaluations.* |
| Qualcomm | ***Proposal 8:*** *For subband full duplex deployment scenario, support to use DL/UL UPT and DL/UL transfer time as evaluation metrics.* |
| DOCOMO | ***Proposal 2:*** *Evaluation assumptions is derived by both UL heavy traffic scenario (e.g. eMBB), and coverage enhancement scenario (e.g. VoIP).* |
| Nokia | ***Proposal 9:*** *For the traffic models and KPIs for SBFD evaluations, assume the following:*   * *FTP3 traffic model with large payload size, e.g. 0.5 MBytes.*    + *Main KPI: User perceived throughput (UPT).*   + *Offered load selected to meet a certain resource utilization (RU) target, e.g. 10% (low load) and 40% (medium load).*   + *Both DL-heavy traffic, 4:1, and symmetric 1:1 DL:UL traffic can be considered.* * *FTP3 traffic model with small payload size, e.g. 32-1500 Bytes or other similar traffic models as discussed during Rel-16 URLLC/IIoT Study Item in TR 38.824.*   + *Main KPIs: CDF of the latency successfully delivered FTP3 packets and/or percentage of UEs meeting certain latency and reliability requirement.*   + *Arrival rate per UE can be fixed, e.g. to 100 packet/second in both UL and DL.*   + *Note: Companies to explicitly account for half-duplex UE limitations preventing the UE to receive and transmit at the same time.* |

* **High-level evaluation methodology**

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| **Company** | **Proposals** |
| Huawei | ***Proposal 10****: At least the following evaluation methodologies should be considered to evaluate Rel-18 NR duplex evolution:*   * *Link budget analysis*   + *Interference strength evaluation for Scenario 2-1, Scenario 3-3, and Scenario 1-3*   + *Coverage evaluation for Scenario 1-3* * *Link level evaluation*   + *Coverage evaluation for Scenario 1-3*   + *Interference suppression evaluation for Scenario 2-1, Scenario 3-3, Scenario 1-3* * *System level evaluation*   + *Coverage and capacity evaluation for Scenario 2-1, Scenario 3-3, and Scenario 1-3*   ***Proposal 11****: Reuse the evaluation methodology, assumptions, and metrics of link budget analysis in IMT-2020 self-evaluation and/or TR 38.830 of Rel-17 NR coverage enhancement for Rel-18 NR duplex evolution.*  ***Proposal 12****: Reuse the evaluation methodology of link level evaluation in TR 38.830 of Rel-17 coverage enhancement for Rel-18 NR duplex evolution and adopt the evaluation assumptions and metrics in Table 6.*  ***Proposal 13****: Reuse the system level evaluation methodology in ITU-R M.2412 for Rel-18 NR duplex evolution and adopt the evaluation assumptions and metrics in Table 7 for system level evaluation.*  ***Proposal 16****: Capture the link budget results in Table 8-9 and the following observations into TR 38.858:*   * *In-band UE-to-UE CLI can be negligible in Scenario 2-1* * *Further enhancements are required to suppress the in-band BS-to-BS CLI in Scenario 2-1*   ***Proposal 17****: Capture the link budget results in Table 10-13 and the following observations into TR 38.858:*   * *Inter-subband BS-to-BS CLI from small cells to small cells and inter-subband UE-to-UE CLI in small cells can be negligible in Scenario 3-3* * *Further enhancements are required to suppress inter-subband BS self CLI in Scenario 3-3* * *Further enhancements are required to handle the BS-to-BS blocking and UE-to-UE blocking issue in Scenario 3-3*   ***Proposal 18****: Capture the link budget results in Table 14-16 and the following observations into TR 38.858:*   * *Inter-subband UE-to-UE CLI in Macro cells can be negligible in Scenario 1-3* * *Further enhancements are required to handle inter-subband BS-to-BS CLI from Macro cells to Macro cells in Scenario 1-3* * *Further enhancements are required to handle inter-subband BS self CLI in Scenario 1-3* * *Further enhancements are required to handle the BS-to-BS blocking and UE-to-UE blocking issue in Scenario 1-3* |
| Ericsson | *Proposal 1: Adopt a net effect model that captures the essential behaviours of a realistic DPD and PA combination with -45 dBc ACLR compliance. This requires input from RAN4.*  *Proposal 2: Adopt a simple crest factor processing model, e.g., hard clipping, that captures the essential behaviours of a BS design to increase transmit power. This requires input from RAN4.*    *Proposal 3 The self-interference channel should be modeled as a set of tapped delay lines directly from TX sub-array ports to RX sub-array ports.*  *Proposal 4 Self-interference channel coefficients should be based on realistic setups supported by real measurements or high-fidelity electromagnetic (EM) evaluations.*  *Proposal 5 The gNB receiver in an SBFD system needs to be carefully studied and modelled with respect to various aspects such as selectivity, linearity etc.*  *Proposal 6 Considering there is no RAN4 requirement on inter-subband selectivity within the channel bandwidth, RAN1/4 needs to study whether the rejection of UL signal in the UL part of an SBFD carrier by a UE receiving DL signal in the DL part is the same as adjacent channel selecitivity requirement.*  *Proposal 7 Send an LS to RAN4 requesting feedback on various radio and antenna modelling aspects that are required for RAN1 to establish evaluation assumptions for both system-level and link-level simulations.* |
| Intel | ***Proposal 3:***   * *Simulation assumptions and evaluation methodologies as agreed during Rel-17 NR coverage enhancement SI can be considered as starting points for evaluation of coverage performance for NOFD operation.* * *Consider Table 1 and Table 2 in the Appendix I for NOFD performance evaluation for FR1 and FR2, respectively.* * *Self-interference modelling should be considered for link-level simulation for NOFD.*   ***Proposal 4:*** *For target reliability and packet size assumptions, User Plane (UP) latency for UL and DL may be evaluated using numerical analyses while using results from link- and system-level evaluations to determine details of UL/DL scheduling flows for PUSCH and PDSCH scheduling.* |
| DOCOMO | ***Proposal 4:*** *Evaluate link level performance with LLS for study on the bandwidth of subband and the bandwidth of guard band for DL and UL subbands*   * *Parameters of “power difference”, “bandwidth of interference channels/subbands”, and “bandwidth of guard band” need to be studied and defined for the evaluation*   ***Proposal 5:*** *Study and define modeling of emissions of interference signal at gNB and UE, respectively for LLS and SLS evaluations.*  ***Observations :***   * *eMBB FR1 : Degradation of 0.1 dB is observed when guard band is 5 RBs and PSD difference is 30 dB, and no degradation is observed when guard band is 25 RBs with 10, 20, 30 dB PSD difference.*   + *PSD difference and guard bandwidth are key parameters for the evaluation and it should be studied and defined* * *eMBB FR2 : Degradation of 2.7 dB, 0.3 dB are observed for 1 PRB and 6 PRBs guard band with 30 dB PSD difference, respectively.*   + *Since required SNR for the target BLER is higher, wider guard band or small PSD difference is required* * *VoIP : Degradation of 3.0 dB, 0.6 dB are observed for 5 PRBs and 25 PRBs guard band with 40 dB PSD difference for FR1.*   + *Larger bandwith of interference signals is one of the reasons for the degradation* |
| Qualcomm | ***Proposal 6:*** *Support SLS as main tool for the evaluation of subband full duplex study.*  ***Proposal 27:*** *RAN 1 shall consider simulation parameters Table 6 FR1 evaluation on Dynamic/flexible TDD*  ***Proposal 28:*** *RAN 1 shall consider simulation parameters in Tables 1, 3, and 7 for FR2 dynamic/flexible TDD evaluation. The bandwidth configuration dynamic/flexible TDD evaluation could be either all for DL or all for UL at least for FR2.* |
| CATT | ***Proposal 3:*** *System-level evaluation is used for Rel-18 SBFD and flexible/dynamic TDD evaluation.*  ***Proposal 9:*** *Perform system platform calibration for SBFD evaluation with SINR CDF.*  ***Proposal 13:*** *Co-channel co-existing of SBFD with legacy TDD is studied in RAN1 and adjacent channel co-existence is led by RAN4.* |
| CMCC | ***Proposal 3:*** *No calibration phase is needed for the evaluation of dynamic/flexible TDD.*  ***Proposal 4:*** *Regarding the evaluation work of SBFD, if majority think it is necessary to have a calibration phase before performance evaluation, the following can be considered:*   * *Phase-1: Conduct calibration based on RAN1’s assumption on the interference modelling for self-interference, gNB-gNB and UE-UE inter-subband CLI, gNB-gNB and UE-UE inter-operator (i.e. adjacent-channel) CLI.* * *Phase-2: Conduct performance evaluation based on RAN4’s input on the interference modelling for self-interference, gNB-gNB and UE-UE inter-subband CLI, gNB-gNB and UE-UE inter-operator (i.e. adjacent-channel) CLI.*   ***Proposal 22:*** *One or multiple of the following scenarios can be considered for SBFD calibration:*   * *Scenario A1 (FR1, FR2): Indoor hotspot with common UL/DL subband configuration* * *Scenario A2 (FR1, FR2): Urban Micro or Dense Urban micro layer with common UL/DL subband configuration* * *Scenario A3 (FR1): Urban Macro with common UL/DL subband configuration*   ***Proposal 23:*** *One or multiple of the following metrics can be used for Phase-1 calibration*   * *Metric 1: CDF of coupling loss (serving cell) from port 0* * *Metric 2: CDF of DL wideband SINR considering legacy gNB-UE interference only* * *Metric 3: CDF of SBFD DL SINR before receiver considering legacy gNB-UE interference and co-channel UE-UE inter-subband CLI* * *Metric 4: CDF of legacy UL SINR before receiver considering legacy UE-gNB interference only* * *Metric 5: CDF of SBFD UL SINR before receiver considering legacy UE-gNB interference, self-interference and co-channel gNB-gNB inter-subband CLI* * *FFS: definition of the above metrics*   ***Proposal 24:*** *Scenario specific parameters as shown in Table 12 can be considered as a starting point for Phase-1 calibration.* |
| New H3C | ***Proposal 1:*** *The system level simulation is used for evaluation on NR duplex evolution.*  ***Proposal 2:*** *Simulation assumption on flexible duplex in TR38.802 is used as starting point for evaluation on NR duplex evolution.*  ***Proposal 3:*** *Above-mentioned table 1, table 2 and table 2 related Simulation parameters are made as baseline for evaluation on NR duplex evolution.* |

### Summary

The performance metrics for SBFD or dynamic/flexible TDD evaluation are summarized as below:

* DL/UL UPT or User Throughput
  + *CMCC, Spreadtrum, BUPT, CATT, vivo, xiaomi, Samsung, Intel, Qualcomm, Ericsson, OPPO, LG*
* DL/UL Latency
  + *Spreadtrum, BUPT, vivo, xiaomi, Samsung, LG, CEWiT, Intel, Qualcomm*
* DL/UL received SINR for calibration
  + *CMCC, Spreadtrum, BUPT, vivo, Samsung, OPPO, CEWiT*
* Coverage, e.g., MPL
  + *Spreadtrum, Ericsson*
* Resource utilization
  + *vivo, Ericsson*
* Cell capacity
  + *ZTE*

Regarding performance metrics, moderator suggests **Initial proposal 4-1-1**.

Regarding the traffic model, the following are proposed by companies:

* FTP3
  + *ZTE, vivo, Nokia, CATT, etc.*
* XR
  + *ZTE*
* VoIP
  + *DOCOMO*

Ericsson suggests that:

* In system level simulation, for the initial phase of performance evaluation comparison is performed between different duplex modes based on the same amount of input traffic within each network.
* For co-existence evaluations (e.g. between two networks), in addition to the case of same input traffic in the two networks, also consider high input traffic in the aggressor and low in the victim.

ZTE suggests that DL and UL need to be simulated simultaneously in the same system.

Regarding traffic model for SLS, moderator suggests **Initial proposal 4-1-2**.

Regarding the high-level evaluation methodologies, most companies think SLS should be used for DL/UL UPT and latency evaluation. In addition to SLS, some companies [Huawei, Intel, Ericsson] also suggest to reuse the link level evaluation methodology in TR 38.830 (i.e., LLS + Link budget analysis) as a start to evaluate the coverage performance (e.g., MPL, MCL, MIL) for SBFD. One company [DoCoMo] suggests to use LLS for study on the bandwidth of subband and the bandwidth of guard band for DL and UL subbands for SBFD.

Regarding high-level evaluation methodologies, moderator suggests **Initial question 4-1-3**.

Some companies [ZTE, CATT, CMCC] suggest RAN1 to conduct SLS calibration before performance evaluation for SBFD as below:

* Phase-1: Conduct calibration based on RAN1’s assumption on the interference modelling for self-interference, gNB-gNB and UE-UE inter-subband CLI, gNB-gNB and UE-UE inter-operator (i.e. adjacent-channel) CLI.
* Phase-2: Conduct performance evaluation based on RAN4’s input on the interference modelling for self-interference, gNB-gNB and UE-UE inter-subband CLI, gNB-gNB and UE-UE inter-operator (i.e. adjacent-channel) CLI.

CMCC suggests the following metrics for RAN1 calibration of SBFD SLS platform:

* Legacy metrics:
  + Metric 1: CDF of coupling loss (serving cell) from port 0
  + Metric 2: CDF of DL wideband SINR considering legacy gNB-UE interference only
* New metrics:
  + Metric 3: CDF of SBFD DL SINR before receiver considering legacy gNB-UE interference and co-channel UE-UE inter-subband CLI
  + Metric 4: CDF of legacy UL SINR before receiver considering legacy UE-gNB interference only
  + Metric 5: CDF of SBFD UL SINR before receiver considering legacy UE-gNB interference, self-interference and co-channel gNB-gNB inter-subband CLI

Regarding SLS calibration for SBFD, moderator suggests **Initial question 4-1-4**.

### 1st Round Proposals

#### ***Initial proposal 4-1-1:***

At least the following metrics are considered for SLS for SBFD and dynamic/flexible TDD evaluation.

* DL/UL UPT or user throughput (CDF or {mean, 5%, 50%, 95%})
* Latency (CDF or {mean, 5%, 50%, 95%})
* Resource utilization
* FFS: DL/UL received SINR for SLS calibration, if RAN1 concludes SLS calibration is needed
* FFS: definitions of the above metrics
* FFS: other metrics

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support |
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|  |  |
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#### ***Initial proposal 4-1-2:***

Regarding traffic model for SBFD and dynamic/flexible TDD evaluation, at least FTP3 is considered.

* FFS: other traffic models, e.g., XR, VoIP
* FFS: Packet size, traffic load, ratio of DL/UL traffic
* Performance evaluation comparison between different duplex modes (e.g., legacy static TDD vs. SBFD) should be performed based on the same amount of input traffic.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support. The third sub-bullet should be merged into the main bullet. |
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#### ***Initial question 4-1-3:***

Whether to reuse the link level evaluation methodology in TR 38.830 (i.e., LLS + Link budget analysis) as a starting point to evaluate the coverage performance of SBFD? Whether the similar performance metrics (e.g., MPL, MCL, MIL) defined in TR 38.830 for Rel-17 coverage enhancement are considered as the performance metrics for SBFD evaluation?

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | We think it is beneficial to support link-budget and LLS to evaluate the proper impact on UE DL performance in presence of inter-UE CLI and impact on gNB UL reception in presence of SI. |
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#### ***Initial question 4-1-4:***

Whether RAN1 needs to conduct SLS calibration for SBFD evaluation or not? What’s your view regarding taking the following metrics for SBFD SLS calibration as a starting point?

* Legacy metrics:
  + Metric 1: CDF of coupling loss (serving cell) from port 0
  + Metric 2: CDF of DL wideband SINR considering legacy gNB-UE interference only
* New metrics:
  + Metric 3: CDF of SBFD DL SINR before receiver considering legacy gNB-UE interference and UE-UE co-channel inter-subband CLI
  + Metric 4: CDF of legacy UL SINR before receiver considering legacy UE-gNB interference only
  + Metric 5: CDF of SBFD UL SINR before receiver considering legacy UE-gNB interference, self-interference and gNB-gNB co-channel inter-subband CLI
* FFS: detailed definitions of these metrics

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | It is helpful to conduct SLS calibration for SBFD to align results across the companies. However, we are concerned about the impact on the progress of the study. |
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## Issue #4-2: SBFD Subband configuration

### Background and submitted proposal

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| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Observation 2:*** *Two SBFD configuration can be considered, i.e.,*   * *SBFD configuration#1: DXXXU, with one UL subband between two DL subbands in slot X.* * *SBFD configuration#2: DXXXU, with one DL subband and one UL subband in slot X.*   ***Proposal 9:*** *SFBD configuration#1 as well as the resource allocation pattern in slot X as following can be used for Phase-1 calibration.*   * *Top/bottom DL subband BW in RB (x/2): 107 RB for FR1 and 103 RB for FR2.* * *Centre UL subband BW in RB (y): 53 RB for FR1 and 52 RB for FR2.* * *Guard band BW at one side in RB (z): 3 RB for both FR1 and FR2.* |
| CATT | ***Proposal 8:*** *FFS the guard band required between UL and DL subbands.*  ***Proposal 12:*** *Adopt semi-static TDD as baseline for SBFD evaluation.*   * *FFS dynamic TDD* |
| xiaomi | ***Observation:*** *Scenarios wherein different UL subband are configured across gNBs can be deferred until we have progress in section 9.3.2.* |
| Samsung | *Proposal 11: RAN1 takes the parameters for duplex evolution in Table 7.*  *SBFD: DXXXU*  *\* X slot contains BWUL MHz for UL at the center and remaining bandwidth for DL, where BWUL = [20] MHz for FR1 and [40] MHz for FR2.*  *\* Guard band can be further considered to suppress inter-subband interference* |
| OPPO | ***Proposal 2:*** *For evaluation purpose, there can be two types of uplink-downlink subband allocation in a carrier:*   * *Type 1: one or more downlink subband and one or more uplink subband within one symbol/slot* * *Type 2: only one downlink subband and only one uplink subband within one symbol/slot* |
| Panasonic | ***Proposal 1:*** *The following assumptions can be considered for link-level simulation.*   * *Scenarios used for coverage enhancement evaluation can be a starting point.* * *Typical subband allocation can be that edges of a band are for DL and the center of a band is for UL.* * *For DL evaluation, CLI due to time difference between DL and UL symbols needs to be taken into account if DL and UL are assumed as in-band.*   ***Observation 1:*** *Guard band can mitigate inter-UE CLI from adjacent subband.*  ***Observation 2:*** *CLI measurement/repot from UE would be useful for the adjustment of guard band.* |
| DOCOMO | ***Proposal 3:*** *Frequency allocation of UL subband at middle PRBs is prioritized for the study and evaluation.* |
| LG | ***Proposal 6:*** *Discuss the location and ratio of wideband half-duplex resource and sub-band full duplex resource for evaluation of subband non-overlapping full duplex.*  ***Proposal 7:*** *Discuss DL/UL subband size, and guard band size for evaluation of subband non-overlapping full duplex.* |
| MediaTek | ***Proposal 7:*** *For SBFD, UL subbands are assumed in DL slots. The UL subbands can be in the centre of the channel bandwidth or at the edge channel bandwidth.*  ***Proposal 8:*** *DL subbands in UL slots are not considered for SBFD scheme.* |
| Qualcomm | ***Observation 8:*** *For SLS evaluation, SBFD is transparent to the UE where all slots are flexible from UE perspective. gNB dynamically schedules the UE within the UL or DL subbands of the SBFD slot.*   * *Full band CSI (SRS and CSI-RS) can be enabled at some non-SBFD symbols*   ***Proposal 12:*** *Support the following slot format configurations for the evaluation of subband full duplex.*   * *For subband full duplex deployment scenario, use same full duplex slot format XXXXX (X=FD=D+U).*   + *Note: all slots are flexible from the UE perspective.* * *For legacy TDD deployment scenario, use DDDSU as defined in Table A.1-2 of 38.838.*   ***Proposal 13:*** *For FR2, for legacy TDD deployment scenario and subband full duplex deployment scenario,*   * *Support periodic reserved DL-only slots and UL-only slots for common control channels*   + *E.g. 20 slots per 20 ms for SSB, 20 slots per 160 ms for PRACH*   ***Proposal 14:*** *For subband full duplex deployment scenario, support configurable N1 RBs DL subbands, N2 RBs UL subbands and N3 RBs as the gap between the DL and UL subbands*   * *Option 1: Support ~40% RBs for each of the two DL subbands (N1=2x~40% RBs) and ~20% RBs for UL subband in middle (N2=~20% RBs) and guard band in between*   + *N or 0 RB for the gap between DL and UL subbands (N3=2xN or 0 RB)* * *Option 2: For FR2, support fully overlapping DL/UL band configuration (N1=N2=entire BW and N3=0)* |
| Huawei | ***Proposal 14:*** *Realistic deployment limitations should be considered for the baseline of the evaluation, such as the backhaul delay, antenna port radiation pattern, etc.*  Proposal 15: Realistic deployment configurations and fair configurations should be taken into account for the baseline selection, such as legacy TDD with frame structure as DDDSU and DDSUU. |
| vivo | *Proposal 6: For the study of performance gain by SBFD, following baseline schemes can be compared with*   * *1st baseline: TDD with semi-static UL-DL configuration.* * *2nd baseline: dynamic TDD*   *Proposal 7: For fair comparison between semi-static SBFD and semi-static TDD, the DL-to-UL resource ratio is assumed to be the same.*  *Proposal 8: For SBFD with dynamic frequency format, the baseline is case 2-1.*   * *Case 2-1: Dynamic TDD (Baseline 2)* |

### Summary

In time domain, the following frame structures for SBFD are suggested by companies [CMCC, Samsung, Qualcomm, etc.]:

* Frame structure#1: DXXXU, where, X is the SBFD slot with DL subband(s) and UL subband.
  + Regarding using DL-only for the first slot, one reason is that some DL-only slots may be needed for transmitting SSBs and it may not available for SBFD operation, and another reason is that it can be used to schedule wideband (e.g., full bandwidth) DL transmission or for legacy UE not supporting SBFD operation. The reason to use UL-only for the last slot is that DDDSU is commonly used in commercial static TDD network, and it is not desired to introduce DL subband in the last uplink slot since it will cause gNB-gNB inter-operator CLI which may degrade the network performance of the adjacent operator.
* Frame structure#2: XXXXU
* Frame structure#3: XXXXX

Regarding the frame structures for SBFD evaluation, moderator suggests **Initial proposal 4-2-1**.

In frequency domain, two types of SBFD subband configurations in SBFD slots are proposed by companies:

* Subband configuration#1: 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
  + *CMCC, Samsung, OPPO, MediaTek*
* Subband configuration#2: 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
  + *CMCC, OPPO, Panasonic, DOCOMO, MediaTek, Qualcomm*

These two SBFD subband configurations can be described using {BD, BU, BG} as below:

* Subband configuration#1: {BD, BU, BG}={2\*ND, NU, 2\*NG}
* Subband configuration#2: {BD, BU, BG}={ND, NU, NG}
* BD: the total number of RBs in all DL subband(s)
* BU: the total number of RBs in all UL subband(s)
* BG: the total number of RBs in all the guard band(s) between UL and DL subbands
* ND: the number of RBs in one DL subband
* NU: the number of RBs in one UL subband
* NG: the number of RBs in one guard band between one UL subband and one DL subband

Regarding the SBFD subband configuration, moderator suggests **Initial proposal 4-2-2**.

 

Subband configuration#1 Subband configuration#2

Regarding the performance evaluation and comparison between legacy TDD operation and SBFD operation, the following two options are proposed by companies as the baseline for legacy TDD operation:

* Opt 1: semi-static TDD
  + Huawei, CATT, vivo, xiaomi, CEWiT
* Opt 2: dynamic TDD
  + vivo (2nd priority)

For Opt 1 (semi-static TDD), some companies [vivo, CEWiT] suggest to use the same DL-to-UL resource ratio between SBFD and semi-static TDD.

Moderator suggests **Initial proposal 4-2-3**.

### 1st Round Proposals

#### ***Initial proposal 4-2-1:***

Consider at least one of the following TDD frame structures for SBFD evaluation:

* Frame structure#1: DXXXU, where X denotes the SBFD slot with DL subband(s) and UL subband.
* Frame structure#2: XXXXU, where X denotes the SBFD slot with DL subband(s) and UL subband.
* Frame structure#3: XXXXX, where X denotes the SBFD slot with DL subband(s) and UL subband.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support frame structure #3 as baseline.  For FR2, for legacy TDD, SBFD and dynamic TDD, support periodic reserved D-only and U-only slots for common control channels, e.g. 20 slots per 20ms for SSB, 20 slots per 160ms for PRACH. |
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#### ***Initial proposal 4-2-2:***

Consider two SBFD subband configurations as below:

* SBFD Subband configuration#1: {BD, BU, BG}={2\*ND, NU, 2\*NG}, 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.
* SBFD Subband configuration#2: {BD, BU, BG}={ND, NU, NG}, 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.
* BD: the total number of RBs in all DL subband(s)
* BU: the total number of RBs in all UL subband(s)
* BG: the total number of RBs in all the guard band(s) between UL and DL subbands
* ND: the number of RBs in one DL subband
* NU: the number of RBs in one UL subband
* NG: the number of RBs in one guard band between one UL subband and one DL subband
* FFS: which configuration(s) is(are) used for evaluation.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | For SLS evaluation, support subband configuration #1.  For FR2, support fully overlapped full duplex configuration as optional evaluation. |
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#### ***Initial proposal 4-2-3:***

For performance evaluation and comparison between legacy TDD operation and SBFD operation under SBFD Deployment Case 1 (Non-coexistence case with single SBFD subband configuration), the following is considered as the baseline for legacy TDD operation:

* Baseline: Static TDD UL/DL configuration with {DDDSU}, where S=10D:2G:2U
  + FFS: whether other TDD UL/DL configurations ((e.g., the same DL-to-UL resource ratio between SBFD and static TDD) can optionally be used as the baseline.
  + FFS: whether dynamic TDD can optionally be used as the baseline.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support |
|  |  |
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## Issue #4-3: Antenna configuration

### Background and submitted proposal

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 15:*** *The separate-Tx/Rx antenna architecture can be described with the following parameters:*   * *Legacy parameters: , , ,* * *New parameters:*   *wherein, there are one Tx antenna array and one Rx antenna array spaced in the horizontal direction with a spacing of and in the vertical direction with a spacing of .*  ***Proposal 16:*** *For separate-Tx/Rx antenna architecture, switched connection between Tx/Rx RFFE and antenna array is preferred, as illustrated in Figure 7 (c), i.e.,*   * *In DL slot, the Tx RFFE connects to the 1st half of antenna array.* * *In SBFD slot, the Tx RFFE connects to the 1st half of antenna array, and the Rx RFFE connects to the 2nd part of antenna array.* * *In UL only slot, the Rx RFFE connects to the 1st half of antenna array.*     ***Proposal 17:*** *For evaluation and comparison between SBFD and legacy TDD, separate-Tx/Rx antenna architecture is assumed for SBFD, and the total number of antenna elements of separate-Tx/Rx antenna assumed for SBFD is two times of the total number of antenna elements of shared-Tx/Rx antenna assumed for legacy TDD.*  ***Proposal 18:*** *Use the shared-Tx/Rx antenna configurations in Table 10 for evaluation of legacy TDD operation.*  Table 10 The shared-Tx/Rx antenna configuration for legacy TDD.   |  |  | | --- | --- | | **Scenarios** | **Antenna configuration at TRxP** | | **Scenario A1 in FR1 (4 GHz)** | (M,N,P,Mg,Ng;Mp,Np) = (2,1,2,1,1;2,1), (dH,dV) = (0.5, 0.5)λ  +45°, -45° polarization | | **Scenario A1 in FR2 (30 GHz)** | (M,N,P,Mg,Ng;Mp,Np) = (4,8,2,1,1;2,2), (dH,dV) = (0.5, 0.5)λ  +45°, -45° polarization | | **Scenario A2 in FR1 (4 GHz)** | (M,N,P,Mg,Ng;Mp,Np) = (8,8,2,1,1;2,8), (dH,dV) = (0.5, 0.8)λ  +45°, -45° polarization | | **Scenario A2 in FR2 (30 GHz)** | (M,N,P,Mg,Ng;Mp,Np) = (4,8,2,2,2;2,8), (dH,dV) = (0.5, 0.5)λ. (dg,H,dg,V) = (4.0, 2.0)λ  +45°, -45° polarization | | **Scenario A3/C3/D3 in FR1 (4 GHz)** | (M,N,P,Mg,Ng;Mp,Np) = (12,8,2,1,1;4,8), (dH,dV) = (0.5, 0.8)λ  +45°, -45° polarization |   ***Proposal 19:*** *Use the separate-Tx/Rx antenna configurations in Table 11 for evaluation of SBFD.*  Table 11 The separate-Tx/Rx antenna configuration for SBFD for Phase-1 calibration.   |  |  | | --- | --- | |  | **Number of antenna elements per TRxP** | | **Scenario A1 in FR1 (4 GHz)** | (da,H, da,V) = (N/A, [5]) λ  *(Note: λ corresponds to 7.5cm)*  For each Tx/Rx antenna:  (M,N,P,Mg,Ng;Mp,Np) = (2,1,2,1,1;2,1), (dH,dV) = (0.5, 0.5)λ  +45°, -45° polarization | | **Scenario A1 in FR2 (30 GHz)** | (da,H, da,V) = (N/A, [32]) λ  *(Note: λ corresponds to 1cm)*  For each Tx/Rx antenna:  (M,N,P,Mg,Ng;Mp,Np) = (4,8,2,1,1;2,2), (dH,dV) = (0.5, 0.5)λ  +45°, -45° polarization | | **Scenario A2 in FR1 (4 GHz)** | (da,H, da,V) = (N/A, [10.4]) λ  *(Note: λ corresponds to 7.5cm)*  For each Tx/Rx antenna:  (M,N,P,Mg,Ng;Mp,Np) = (8,8,2,1,1;2,8), (dH,dV) = (0.5, 0.8)λ  +45°, -45° polarization | | **Scenario A2 in FR2 (30 GHz)** | (da,H, da,V) = (N/A, [34]) λ  *(Note: λ corresponds to 1cm)*  For each Tx/Rx antenna:  (M,N,P,Mg,Ng;Mp,Np) = (4,8,2,2,2;2,8), (dH,dV) = (0.5, 0.5)λ. (dg,H,dg,V) = (4.0, 2.0)λ  +45°, -45° polarization | | **Scenario A3/C3/D3 in FR1 (4 GHz)** | (da,H, da,V) = (N/A, [10.4]) λ  *(Note: λ corresponds to 7.5cm)*  For each Tx/Rx antenna:  (M,N,P,Mg,Ng;Mp,Np) = (12,8,2,1,1;4,8), (dH,dV) = (0.5, 0.8)λ  +45°, -45° polarization | |
| Samsung | *Proposal 9: For evaluation of SBFD operation, RAN1 takes the following two cases for BS antenna configuration.*   * *Case 1. Half number of antenna elements are used to simultaneously perform DL transmission and UL reception* * *Case 2. The same number of antenna elements are used to simultaneously perform DL transmission and UL reception*   *Proposal 10: For evaluation, RAN1 takes the parameters for BS antenna configurations shown in Table 6 as a starting point.* |
| Ericsson | *Proposal 10: For system level evaluations, when comparing SBFD performance to static TDD, two cases should be considered: SBFD network with 1) same antenna array size (with halved transmit power) and 2) same antenna array gain (with same transmit power) as static TDD network.* |
| KT | ***Observation 1:*** *Using separate panel for Tx/Rx can help reducing Self-Interference*  ***Proposal 2:*** *Consider using separate Tx/Rx panel for the default design of sub-band full duplex gNB* |
| LG | ***Proposal 10:*** *Discuss antenna configuration for half duplex and subband non-overlapping full duplex.* |
| Qualcomm | ***Observation 5:*** *Support separate panels configuration with split of the antenna elements for simultaneous downlink transmission and uplink reception for subband full duplex. Companies can report assumed physical panels separation.*  ***Observation 6:*** *Support single panel configuration with same total number of antenna elements for downlink transmission or uplink reception for legacy TDD.*  ***Proposal 9:*** *For subband full duplex deployment scenario, BS antenna configuration is based on two panels with split of the antenna elements for simultaneous downlink transmission and uplink reception.*  ***Proposal 10:*** *For legacy TDD deployment scenario, BS antenna configuration is based on single panel for downlink transmission or uplink reception.*  ***Observation 7:*** *To further optimize the performance of subband full duplex when traffic is single direction in SBFD slot, TDD-like single panel configuration could be used to improve the beamforming gain.*  ***Proposal 11:*** *At least for FR2, optionally support adaptive antenna array configuration across slots for the subband full duplex evaluation. According to traffic conditions, separate panels configuration shall be used on the subband full duplex slots with scheduled simultaneous downlink and uplink, and TDD-like single panel configuration shall be used on the dynamic TDD slots with scheduled either downlink or uplink.* |

### Summary

To reduce self-interference, several companies [CMCC, Samsung, Ercisson, KT, Qualcomm] propose to use separate-Tx/Rx antenna array architecture for SBFD. CMCC suggests to use the following parameters to describe the separate-Tx/Rx antenna array model:

* Legacy parameters: , , ,
* New parameters:
* Note: there are one Tx antenna array and one Rx antenna array spaced in the horizontal direction with a spacing of and in the vertical direction with a spacing of .

Moderator suggests **Initial proposal 4-3-1 and 4-3-2**.



Separate-Tx/Rx antenna array model.

For evaluation and comparison between SBFD and legacy TDD, when separate-Tx/Rx antenna array is assumed for SBFD, the following options are proposed by companies [Samsung, Ericsson, Qualcomm, CMCC]:

* Opt 1: The total number of antenna elements of separate-Tx/Rx antenna array for SBFD is the same as the total number of antenna elements of shared-Tx/Rx antenna array for legacy TDD.
* Opt 2: The total number of antenna elements of separate-Tx/Rx antenna array for SBFD is two times of the total number of antenna elements of shared-Tx/Rx antenna array for legacy TDD.

CMCC raises that for the shared-Tx/Rx antenna architecture in legacy TDD (as shown in part(a) of the following figure), all the antenna elements can be either connected to Tx RFFE (RF front end) or to Rx RFFE by switching. For SBFD with separate-Tx/Rx antenna architecture, two options of the connection between Tx/Rx RFFE and the antenna array can be considered:

* Candidate 1: Fixed connection. As shown in part(b) of the following figure, Tx RFFE (including DAC and PA) always connected to the Tx antenna array, and Rx RFFE (including LNA and ADC) always connected to the Rx antenna array.
  + **Pros**: Simple.
  + **Cons**: Loss of UL/DL channel reciprocity, since it is hard to perform accurate estimation of DL channel associated with TX antenna array via the SRS reception associated with a different Rx antenna array.
* Candidate 2: Switched connection. As shown in part(c) of the following figure, 1) In DL slot, the Tx RFFE connects to the 1st half of antenna array. 2) In SBFD slot, the Tx RFFE connects to the 1st half of antenna array, and the Rx RFFE connects to the 2nd part of antenna array. 3) In UL only slot, the Rx RFFE connects to the 1st half of antenna array.
  + **Pros**:
    - UL/DL channel reciprocity can be maintained. Note that, the Tx RFFE and the Rx RFFE connect to the same part of antenna array (i.e., the left half of antenna array) in TDM mode, thus, the SRS reception at the Rx RFFE in UL only slot can be used to accurately estimate the DL channel in DL slot or SBFD slots.



(a) shared-Tx/Rx antenna array architecture



(b) Candidate 1 of separate-Tx/Rx antenna array architecture: fixed connection



(c) Candidate 2 of separate-Tx/Rx antenna array architecture: switched connection

Based on the above discussion, CMCC thinks candidate 2 of separate-Tx/Rx antenna array architecture is preferred, and further made the following observations based on the candidate 2 of separate-Tx/Rx antenna array architecture:

* For Opt 1 (with the same number of antenna elements as legacy TDD), the number of TXRUs of separate-Tx/Rx antenna array for SBFD will be half of the number of TXRUs of shared-Tx/Rx antenna array for legacy TDD.
* For Opt 2 (with two times of antenna elements as legacy TDD), the number of TXRUs of separate-Tx/Rx antenna array for SBFD will be the same as the number of TXRUs of shared-Tx/Rx antenna array for legacy TDD.

Qualcomm proposes to optionally support adaptive antenna array configuration across slots for the subband full duplex evaluation at least for FR2, i.e., according to traffic conditions, separate panels configuration shall be used on the subband full duplex slots with scheduled simultaneous downlink and uplink, and TDD-like single panel configuration shall be used on the dynamic TDD slots with scheduled either downlink or uplink. Moderator understands this kind of adaptive antenna array configuration is based on the assumption that the number of antenna elements of the separate-Tx/Rx antenna array for SBFD is the same as the number of antenna elements of shared-Tx/Rx antenna array for legacy TDD, and the number of TXRUs of separate-Tx/Rx antenna for SBFD is also the same as the number of TXRUs of shared-Tx/Rx antenna array for legacy TDD.

Moderator suggests **Initial proposal 4-3-3**.

### 1st Round Proposals

#### ***Initial proposal 4-3-1:***

For SBFD operation, BS antenna configuration is based on two separate antenna arrays with split of the antenna elements for simultaneous downlink transmission and uplink reception.Use the following parameters to describe the separate-Tx/Rx antenna array model.

* Legacy parameters *, , ,* , as defined in section 7.3 in TR.38.901, are used to describe the Tx antenna array or Rx antenna array.
* New parameters are used to describe the relative location between Tx antenna array and Rx antenna array.
  + For one separate-Tx/Rx antenna array, there are one Tx antenna array and one Rx antenna array spaced in the horizontal direction with a spacing ofand in the vertical direction with a spacing o*f .*

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | We support main bullet and first sub-bullet. Companies can report the configured panel separation if needed. |
|  |  |
|  |  |
|  |  |

#### ***Initial proposal 4-3-2:***

For legacy TDD operation, BS antenna configuration is based on single antenna array for downlink transmission or uplink reception, which can be called as shared-Tx/Rx antenna array.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| QC | Support |
|  |  |
|  |  |
|  |  |

#### ***Initial proposal 4-3-3:***

For evaluation and comparison between SBFD and legacy TDD, when separate-Tx/Rx antenna array is assumed for SBFD, consider the following options:

* Opt 1: The total number of antenna elements of separate-Tx/Rx antenna array for SBFD is the same as the total number of antenna elements of shared-Tx/Rx antenna array for legacy TDD.
* Opt 2: The total number of antenna elements of separate-Tx/Rx antenna array for SBFD is two times of the total number of antenna elements of shared-Tx/Rx antenna array for legacy TDD.
* FFS: the assumption on the relationship between the number of TXRUs of separate-Tx/Rx antenna array for SBFD and the number of TXRUs of shared-Tx/Rx antenna array for legacy TDD.

Companies are encouraged to provide comments in the table below.

|  |  |
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| **Company** | **Comment** |
| QC | Prefer Opt 1 for fair comparison with the same #TxRUs for SBFD and legacy TDD.  At least for FR2, support adaptive antenna array configuration across slots for additional SBFD evaluation. According to traffic conditions, separate panels configuration shall be used on the subband full duplex slots with scheduled simultaneous downlink and uplink, and TDD-like single panel configuration shall be used on the dynamic TDD slots with scheduled either D or U. |
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## Issue #4-4: Channel model

### Background and submitted proposal

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| **Company** | **Proposals** |
| CMCC | ***Proposal 10:*** *For TRxP-TRxP channel model:*   * *In scenario A1, reuse the channel model for indoor-Office (Open office) in TR 38.901 as the channel model for TRxP-TRxP by setting .* * *In scenarios A2, reuse the channel model for UMi-Street Canyon in TR 38.901 as the channel model for TRxP-TRxP by setting .* * *In scenarios A3/C3/D3, reuse the channel model for UMa in TR 38.901 as the channel model for TRxP-TRxP by setting .*   ***Proposal 11:*** *For UE-UE channel mode, Opt 1 of the following options can be used:*   * *Opt 1: Reuse the channel model for gNB-UE in TR 38.901 as the channel model for UE-UE by setting ., e.g.,*    + *In scenario A1, reuse the channel model for indoor-Office (Open office) in TR 38.901 as the channel model for UE-UE by setting .*   + *In scenario A2/A3/C3/D3, reuse the channel model for UMi-Street canyon in TR 38.901 as the channel model for UE-UE by setting .* * *Opt 2: Reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802.*   ***Proposal 12:*** *For UE-UE channel model, the applicability range of the pathloss model for UMi-Street canyon in Table 7.4.1-1 in TR 38.901 is extended from to , e.g., X = [3].*  ***Proposal 13:*** *At least for calibration, only large-scale fading needs to be modelled for UE-UE channel.*  ***Proposal 14:*** *In scenarios A2/A3/C3/D3, the penetration loss between UEs can follows Table A.2.1-13 and A.2.1-12 in TR 38.802 for FR1 and FR2 respectively.* |
| Huawei | ***Observation 5:*** *The LOS probability of BS-to-BS link determined by reusing BS-to-UE channel model in TR 38.901 with modifications in TR 38.802 is much lower than that in the realistic network. It will lead to that the BS-to-BS CLI strength level in the evaluation is much lower than that in the actual network.*  ***Proposal 9****: Reuse the existing BS-to-UE channel model in TR 38.901 and TR 38.802 as much as possible to determine the BS-to-BS channel and UE-to-UE channel in Rel-18 NR duplex evolution.*   * *FFS: the parameters, e.g., LOS probability, delay spread, angle spread, etc., in the BS-to-UE channel model should be checked whether they are applicable to the BS-to-BS channel model and UE-to-UE channel model.* |
| ZTE | ***Proposal 11****: For Subband full duplex and dynamic TDD simulation,*   * *RAN1 considers channel model with both large scale (e.g., path loss and penetration loss) and small scale (e.g., fast fading) for co-channel gNB-gNB channel model.* * *RAN1 considers channel model with large scale (e.g., path loss and penetration loss) for adjacent channel gNB-gNB channel model.* * *RAN1 considers channel model with large scale (e.g., path loss and penetration loss) for UE-UE co-channel and adjacent channel model.*   ***Proposal 12****: Regarding channel model for simulation of subband duplex and dynamic TDD*   * *gNB-gNB channel model: reusing the 38.901 channel model by replacing the UE’s antenna height with victim gNB’s antenna height;* * *UE-UE channel model: reusing the 38.901 channel model by replacing the gNB’s antenna height with aggressor UE’s antenna height;* * *FFS LOS probability* |
| vivo | *Proposal 11: The channel model in TR38.901 with necessary modification can be used for BS-to-BS and UE-to-UE channel modeling.* |
| xiaomi | ***Proposal 7:*** *Study and determine the channel model for different links. The following assumption can be the starting point:*   * *gNB-to-gNB, reuse the channel model defined in TR38.901* * *gNB-to-UE, reuse the channel model defined in TR38.901* * *UE-to-UE, reuse the channel model defined in TR38.802* |
| Nokia | ***Proposal 10:*** *For the channel models for dynamic TDD and SBFD system-level evaluations, re-use the existing channel models in TR 38.901 as much as possible for gNB-to-UE, gNB-to-gNB and UE-to-UE links.*   * *See Table 2 in this contribution for considerations on channel model and UE and BS height for Urban Macro (UMa), Dense Urban and Indoor Hotspot (InH) scenarios.* * *RAN1 to discuss whether changes to the LOS probability calculations in UMi and InH channel models are needed to explicitly account for the transmitter-receiver height (in both absolute and relative terms).*   Table 2: Channel models for gNB-UE, gNB-gNB and UE-UE links.   |  |  |  |  | | --- | --- | --- | --- | |  | **UMa (500 m ISD)** | **Dense Urban (200 m ISD)** | **Indoor Hotspot (20 m ISD)** | | **gNB-UE** | TR 38.901 UMa | TR 38.901 UMi | TR 38.901 InH | | **gNB-gNB** | TR 38.901 UMa with *h*UE = *h*BS = 25m | TR 38.901 UMi with *h*UE = *h*BS = 10m | TR 38.901 InH with *h*UE = *h*BS = 3m | | **UE-UE** | TR 38.901 UMi with *h*UE = *h*BS | TR 38.901 UMi with *h*UE = *h*BS | TR 38.901 InH with *h*UE = *h*BS = 1.5m |  |  |  |  | | --- | --- | --- | |  | **HetNet (500 m ISD macro layer + outdoor small cells)** | **HetNet (500 m ISD macro layer + indoor small cells)** | | **Macro gNB-UE** | TR 38.901 UMa | TR 38.901 UMa | | **Small cell gNB-UE** | TR 38.901 UMi | TR 38.901 InH | | **Macro-to-Macro** | TR 38.901 UMa with *h*UE = *h*BS = 25m | TR 38.901 UMa with *h*UE = *h*BS = 25m | | **Macro-to-small cell** | TR 38.901 UMa with *h*UE =10m and *h*BS = 25m | TR 38.901 UMa with *h*UE = 3m and *h*BS = 25m, and O2I penetration loss | | **Small cell-to-small cell** | TR 38.901 UMi with *h*UE = *h*BS = 10m | TR 38.901 InH with *h*UE = *h*BS = 3m | | **UE-UE** | TR 38.901 UMi with hUE = hBS | TR 38.901 InH if UEs are in the same office, otherwise UMi. | |
| Intel | ***Proposal 2:*** *Channel models used in Rel-16 CLI/RIM study could be used as a starting point.* |
| Qualcomm | ***Observation 14:*** *gNB-to-gNB channel model by leveraging gNB-to-UE channel model in TR 38.802 / 38.901 with certain changes on UE to mimic a gNB.*  ***Observation 15:*** *UE-to-UE inter-subband CLI model can be done using similar procedure for modelling inter-gNB inter-subband CLI.* |

### Summary

gNB-gNB and UE-UE channel model are needed in RAN1 SLS for SBFD and dynamic/flexible TDD evaluation. ZTE proposes that:

* RAN1 considers channel model with both large scale (e.g., path loss and penetration loss) and small scale (e.g., fast fading) for co-channel gNB-gNB channel model.
* RAN1 considers channel model with large scale (e.g., path loss and penetration loss) for adjacent channel gNB-gNB channel model.
* RAN1 considers channel model with large scale (e.g., path loss and penetration loss) for UE-UE co-channel and adjacent channel model.

Moderator suggests **Initial proposal 4-4-1**.

vivo raises the following observation for gNB-gNB and UE-UE channel model:

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| *In the simulation parameters given in TR 38.828, it is recommended to use the channel model in TR38.803 for BS-to UE and BS-to-BS, while for UE-to-UE the channel model in TR 36.828 is used. The channel model in TR 38.803 does not give a model for small-scale fading, which will lead to a decrease in the accuracy of the simulation results, especially for the BS-to-UE. In addition, the channel model in TR 36.828 is commonly used in LTE evaluation. In previous NR evaluations, the channel model in TR38.901 was widely used. Therefore,*  *For SBFD evaluation, we recommend reusing the channel model in TR38.901 for BS-to-BS and UE-to-UE channel modeling. Some necessary modifications can be considered for the BS-to-BS and UE-to-UE channel modeling.* |

For gNB-gNB channel model, most companies suggest to reuse gNB-to-UE channel model in TR 38.901 with necessary modification, e.g.,

* Replacing the UE’s antenna height with gNB’s antenna height
  + *CMCC, Huawei, ZTE, vivo, xiaomi, Nokia, Intel, Qualcomm*
* FFS: whether/how to update LOS probability.
  + *Huawei, ZTE, Nokia*

Moderator suggests **Initial proposal 4-4-2**.

For UE-UE channel model, two options are proposed by companies:

* Option 1: Reuse the gNB-UE 5GCM in TR 38.901 with necessary modification for both FR1 and FR2, similar as the UE-UE channel model for flexible duplex evaluation in TR38.802 for FR2.
  + Replacing the gNB’s antenna height with UE’s antenna height
    - *CMCC, ZTE, vivo, xiaomi, Nokia, [Qualcomm]*
  + Extending the applicability range of the pathloss model for UMi-Street canyon in Table 7.4.1-1 in TR 38.901 is extended from to , e.g., X = [3]
    - *CMCC*
* Option 2: Reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802 for both FR1 and FR2.
  + *Huawei, Intel*

Moderator suggests **Initial proposal 4-4-3**.

CMCC suggested that the penetration loss between UEs can follows Table A.2.1-13 and A.2.1-12 in TR 38.802 for FR1 and FR2 respectively.

### 1st Round Proposals

#### ***Initial proposal 4-4-1:***

For gNB-gNB channel model and UE-UE channel model in RAN1 SLS:

* Both large scale fading (e.g., path loss, penetration loss, shadowing) and small scale fading (e.g., fast fading including antenna gain) are modeled for co-channel gNB-gNB channel model.
* Only large scale fading (e.g., path loss, penetration loss, shadowing, antenna gain) is modeled for adjacent-channel gNB-gNB channel model.
* Only large scale fading (e.g., path loss, penetration loss, shadowing, antenna gain) is modeled for co-channel and adjacent-channel UE-UE channel model.
* Note: Antenna gain is calculated based on the gNB-gNB or UE-UE LOS direction instead on the multi-path directions if fast fading is not modeled.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | This proposal is related to discussion of 3-4.   * Both large scales fading and small scale fading should be considered for UE-UE co-channel * The co-channel model should be based on TR 38.802 and TR 38.901 with some adjustments on height and angular spread. * Large scale fading considered for adjacent channel UE-UE channel model and adjacent channel BS-BS channel model. |
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#### ***Initial proposal 4-4-2:***

For gNB-gNB channel model, reuse gNB-to-UE channel model in TR 38.901 with necessary modification, e.g.,

* Replacing the UE’s antenna height with gNB’s antenna height.
* FFS: whether/how to update LOS probability.
* FFS: Other details and necessary modifications

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| QC | Support in principle. In addition to antenna height adjustment, angular spread should be updated as well. |
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#### ***Initial proposal 4-4-3:***

For UE-UE channel model, consider the following two options:

* Option 1: Reuse the gNB-UE 5GCM in TR 38.901 with necessary modifications for both FR1 and FR2, similar as the UE-UE channel model for flexible duplex evaluation in TR38.802 for FR2.
  + For Indoor hotspot, reuse the gNB-UE 5GCM Indoor-office in TR38.901, and for Dense urban and Urban macro, reuse the gNB-UE 5GCM UMi-Street canyon in TR38.901 with necessary modification, e.g.,
    - Replacing the gNB’s antenna height with UE’s antenna height, updating ASD and ZSD.
    - FFS: Other details and necessary modifications.
* Option 2: Reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802 for both FR1 and FR2 with necessary modifications.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Issue #4-5: Other issues

### Submitted proposal

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| **Company** | **Proposals** |
| CMCC | ***Proposal 20****: For DL transmission power, the following options can be considered for SBFD.*   * *Opt 1: The DL power spectrum density is kept unchanged over DL only slots and SBFD slots.* * *Opt 2: The DL power spectrum density can be boosted in SBFD slots compared to that in DL only slots.*   ***Proposal 21****: Option 1 for DL transmission power can be used for calibration of SBFD.*   * *Opt 1: The DL power spectrum density is kept unchanged over DL only slots and SBFD slots.*   **On Scenario C3 (FR1)**  ***Proposal 25:*** *No system level simulation is needed for Scenario C3 (Urban Macro considering co-channel co-existence with legacy TDD operation).*  **On Scenario D3 (FR1)**  ***Proposal 26:*** *It is not necessary for RAN1 to perform the performance evaluation for adjacent-channel co-existence between SBFD operation and legacy TDD operation.* |
| Ericsson | *Proposal 13: It is important to consider UE-UE interference in the study which is a potential consequence of the clustered distribution UEs that are of indoors.*  *Proposal 15: In the system level simulations, the scheduled bandwidth for UL transmissions (within a semi-statically configured UL subband) should be adaptive based on achieving a target S(I)NR, for both static TDD and SBFD networks.* |
| LG | ***Proposal 5:*** *DL Tx power control can be applied for evaluation of subband non-overlapping full duplex and dynamic/flexible TDD.* |
| MediaTek | ***Proposal 5:*** *For the evaluations of SBFD and DTDD schemes, RAN1 should consider clustered UEs deployments to accurately capture the impact of inter-UE CLI.* |

# Proposals for GTW session

# References

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2. RP-220633, Revised SID: Study on evolution of NR duplex operation, CMCC
3. R1-2203156 Overview of evaluation on NR duplex evolution Huawei, HiSilicon
4. R1-2203203 Discussion of evaluation on NR duplex evolution ZTE
5. R1-2203214 Discussion for Evaluation on NR duplex evolution New H3C Technologies Co., Ltd.
6. R1-2203327 Discussion on evaluation on NR duplex evolution Spreadtrum Communications, BUPT
7. R1-2203458 Discussion on deployment scenario and evaluation methodology for duplex operation CATT
8. R1-2203557 Evaluation on NR duplex evolution vivo
9. R1-2203814 Discussion on evaluation on NR duplex evolution xiaomi
10. R1-2203903 Deployment scenario and evaluation methodology for duplex evolution Samsung
11. R1-2204021 Discussion on evaluation on NR duplex evolution OPPO
12. R1-2204053 Evaluation on NR duplex evolution SHARP Corporation
13. R1-2204068 Evaluation assumption and methodology for study on NR-duplex InterDigital, Inc.
14. R1-2204106 Evaluation of NR duplex evolution Ericsson
15. R1-2204122 Discussion on deployment scenario of NR duplex evolution KT Corp.
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17. R1-2204244 Initial evaluation on NR duplex evolution Apple
18. R1-2204303 Discussion on evaluation on NR duplex evolution CMCC
19. R1-2204379 Discussion on evaluation on NR duplex evolution NTT DOCOMO, INC.
20. R1-2204430 On the evaluation methodology for NR duplexing enhancements Nokia, Nokia Shanghai Bell
21. R1-2204529 Study on Evaluation for NR duplex evolution LG Electronics
22. R1-2204721 Deployment scenarios and evaluation methodology for NR duplex evolution MediaTek Inc.
23. R1-2204750 Discussion on evaluation on NR duplex evolution CEWiT
24. R1-2204799 On evaluations for NR duplex evolution Intel Corporation
25. R1-2205030 On Deployment scenarios and evaluation Methodology for NR duplex evolution Qualcomm Incorporated