**3GPP TSG RAN WG1 #110**  **R1-22xxxxx**

**Toulouse, France, August 22nd – 26th, 2022**

**Agenda item:** 9.3.1

**Source:** Moderator (CMCC)

**Title:** Summary# on evaluation on 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].

In this contribution, we summarized the related issues and proposals based on the contributions submitted in RAN1#110 under the agenda item 9.3.1 [3]-[28].

The following sections are structured as follows. From section 2 to 4, we categorize the key issues raised by contributions into 3 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.

# Issue#1: Deployment scenarios

## Issue#1-1: Scenarios for SBFD

### Submitted proposal

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| **Company** | **Proposals** |
| CMCC | Table 1 Deployment cases and scenarios for SBFD.   |  |  |  | | --- | --- | --- | | **Deployment Cases** | **Scenarios** | | | **SBFD Deployment Case 1** | **FR1** | * Indoor office [agreed] * Urban Macro [agreed] * Optional: Dense Urban Macro layer, Dense Urban with 2-layer [agreed] | | **FR2-1** | * Indoor office [agreed] * Dense Urban Macro layer [agreed] * Optional: Dense Urban Micro layer [agreed] | | **SBFD Deployment Case 4** | **FR1** | * Urban Macro [agreed] | | **FR2-1** | * Dense Urban Macro layer [agreed] | | **SBFD Deployment Case 3-2** | **FR1** | * Dense Urban with 2-layer * HetNet with Urban Macro and Indoor office (new scenario) | |
| Huawei | **Deployment Case 2**  ***Proposal 3:*** *SBFD Deployment Case 2 can be evaluated with a low priority.*  **Deployment Case 3**  ***Proposal 4:*** *For SBFD Deployment Case 3, HetNet with Urban Macro layer and indoor factory/office layer for FR1 should be considered:*   * *Indoor factory/office layer with SBFD;* * *Urban Macro layer with DL dominant TDD.* |
| ZTE | ***Proposal 3:*** *For SBFD Deployment Case 2, at least consider the following scenarios for evaluation:*   * *For FR1,*   + *Dense Urban with 2-layer (use Dense Urban defined in TR38.802/TR38.901 as starting point)*     - *Macro and micro use different SBFD configurations*   + *(Optional) Urban macro (use Urban macro defined in TR38.802/TR38.901 as starting point)* * *For FR2-1,*   + *(Optional) Dense Urban Macro layer (use Dense Urban defined in TR38.802 as starting point)*   + *(Optional) Dense Urban micro (use Dense Urban micro defined in TR38.802/TR38.901 as starting point)*   ***Proposal 4:*** *For SBFD Deployment Case 3, at least consider the following scenarios for evaluation:*   * *For FR1,*   + *Dense Urban with 2-layer (use Dense Urban defined in TR38.802/TR38.901 as starting point)*     - *Macro and micro use different SBFD configurations*   + *(Optional) Urban macro (use Urban macro defined in TR38.802/TR38.901 as starting point)* * *For FR2-1,*   + *(Optional) Dense Urban Macro layer (use Dense Urban defined in TR38.802 as starting point)*   + *(Optional) Dense Urban micro (use Dense Urban micro defined in TR38.802/TR38.901 as starting point)* |
| Ericsson | ***Proposal 12***: RAN1 to agree that for SBFD evaluation in RAN1, deployment case 1 and case 4 are high priority, while case 3-2 can be done on a best effort basis.  ***Proposal 13***: Regarding evaluation scenarios, two-operator urban macro scenario should be prioritized and considered as the baseline scenario. We do not preclude other scenarios, but it is important to study at least one real-world deployment. |
| Samsung | ***Proposal 1***: *For SBFD deployment cases 2 and 3, the followings are suggested:*   * *Do not evaluate all deployment scenarios (Indoor Hopspot/Office, Dense urban Urban Macro) under Deployment case 2 as mandatory* * *Do not evaluate Indoor Hotspot/Office, Dense Urban (1-layer) and Urban Macro under Deployment case 3 as mandatory*   + *Further discuss whether to evaluate Dense Urban (2-layer), where different layers have different duplex operation.*   ***Proposal 2***: For NR duplex evolution evaluation, FR2-2 is not considered  ***Proposal 3***: For NR duplex evolution evaluation, Rural scenario is not considered as mandatory |
| Qualcomm | ***Observation 1:*** Subband full duplex deployment for Massive MIMO macro cell deployment with large EIRP could benefit from UL coverage gain and latency improvement while it is a challenging deployment due to large self-interference at gNB.  ***Observation 2***: 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 3:*** Deployment case 1 with same UL/DL subband configurations across all cells is more practical from deployment perspective as compared to Deployment case 2.  ***Observation 4:*** Deployment case 4 is important for Rel-18 study to evaluate the effect on the legacy/SBFD operator and legacy UE due to adjacent channel cross-link interference.  ***Proposal 1:*** For Deployment case 1, support HetNet with Urban Macro and Indoor as an optional deployment scenario at least for FR1.  ***Proposal 2:*** For Deployment case 4, Urban Macro (FR1) and Dense Urban Macro layer (FR2-1) deployment are considered as baseline for the study of adjacent channel coexistence between SBFD and static TDD operator.   * Further discussion on additional scenarios of Indoor hotspot and Dense urban Micro layer scenarios. |
| DOCOMO | ***Proposal 1***: Deployment Case 1 should be prioritized for the evaluation, and Case 4 can be considered as the 2nd priority. |
| Nokia, Nokia Shanghai Bell | ***Proposal 3:*** For SBFD evaluation from RAN1 perspective, RAN1 to agree on the evaluation scenarios and assumptions for each of the Deployment Cases 1-4 (with RAN4 coordination, when needed), while it is up to each company to simulate and provide results for each of the agreed deployment cases and scenarios.   * Note: the number of simulation scenarios should be kept relatively small to ensure that sufficient number of simulation results per scenario are collected and conclusions can be drawn.   ***Proposal 4***: System-level evaluations for Deployment Case 4 (adjacent-channel coexistence case) should only be pursued if there are significant changes on the parameters/assumptions compared to the previous Rel-16 TDD adjacent coexistence studies, e.g. in terms of gNB ACLR/ACS.  ***Proposal 5:*** For evaluation of SBFD Deployment Case 1, FR1 Rural and FR2-2 are not considered.  ***Proposal 6:*** For evaluation of SBFD Deployment Case 4 (Adjacent-channel co-existence case), consider Urban Macro (FR1) and Dense urban (FR1, FR2) as the main scenarios.  ***Proposal 7:*** For evaluation of SBFD Deployment Case 2 and 3, consider the following deployment scenarios:   * Deployment Case 2: Reuse the scenarios agreed for Deployment Case 1. * Deployment Case 3-2 (2-layer): Adopt similar scenario as for flexible/dynamic TDD evaluations e.g.: HetNet with Urban Macro and Indoor office deployed in the same carrier. Macro gNBs use DL dominant static TDD UL/DL configuration and indoor gNBs use SBFD operation with the same SBFD subband configuration. |
| MediaTek | ***Proposal 1:*** No further prioritization between the deployment cases for SBFD is pursued in RAN1. |
| LG | ***Proposal 1:*** *For deployment scenarios of study on NR duplex evolution, Rural is not included as a deployment scenario for evaluation in Rel-18 DE SI.*  ***Proposal 2:*** *Considering on work load for evaluation in Rel-18 DE SI, FR2-2 is not considered in Rel-18, and FR2-2 is considered in future release.* |
| Spreadtrum, BUPT | ***Proposal 1:*** For SBFD case, prefer priority order: case1>case4>case2,3 |
| Xiaomi | ***Proposal 1:*** For deployment case 1, indoor office/urban macro/dense urban defined in TR38.802/TR38.901 should be reused:   * 80% indoor UE and 20% outdoor UE is assumed * Deprioritize Rural scenario * FR2-2 is not considered for SBFD evaluation.   ***Proposal 2:*** SBFD Deployment Case 2 can be deprioritized and the following scenarios for evaluation can be considered in the future:   * For FR1,   + Indoor office (use Indoor office defined in TR38.802/TR38.901 as starting point)   + Urban macro (use Urban macro defined in TR38.802/TR38.901 as starting point)     - 20% outdoor UE /80% indoor UE   + Optional: Dense Urban with 1-layer or 2-layer (use Dense Urban defined in TR38.802/TR38.901 as starting point) * For FR2-1,   + Indoor office (use Indoor office defined in TR38.802/TR38.901 as starting point)   + Dense Urban Macro layer (use Dense Urban defined in TR38.802 as starting point)     - 20% outdoor UE /80% indoor UE   + Optional: Dense Urban micro (use Dense Urban micro defined in TR38.802/TR38.901 as starting point)   ***Proposal 3:*** The following aspects corresponding to deployment case 3 need to be further clarified:   * For 1-layer case, dense urban Macro or Urban macro scenario is adopted * For 2-layer case, dense urban Macro with two layers is adopted   + The SFBD gNB deployment needs further clarification, i.e. per layer deployment or mixed deployment across layers.     Figure1:Examples of 2-layer scenarios for co-existence between legacy TDD gNB and SBFD gNB |
| InterDigital | ***Proposal 2.*** *Urban macro and indoor scenarios can be considered for evaluations in this study, where the indoor scenarios represent the most significant UE-to-UE CLI effects.* |
| New H3C | ***Proposal 1:*** For SBFD Deployment Case 1, FR2-2 should be deprioritized for both SBFD operation and flexible TDD. |
| CATT | ***Proposal 1***: FR 2-2 is deprioritized in Rel-18 duplex evolution SI. |
| Intel | ***Proposal 1:*** Studies/evaluations of SBFD and flexible/dynamic TDD in FR2-2 are deprioritized and can be revisited later depending on progress.  ***Proposal 2:*** RAN1 to confirm that same deployment scenarios agreed for SBFD deployment case 1 are also considered for SBFD case 2 and 3 with single layer. |
| Apple | ***Proposal 1:*** Full-duplex operation shall not be supported for macro-to-macro scenarios, at least for FR1. |
|  |  |

### Summary

**SBFD Deployment Case 1**

Regarding Rural for FR1, 4 companies [Samsung, Nokia, LG, Xiaomi] suggest to deprioritize or not consider Rural scenario as mandatory for Rel-18 NR duplex evolution study phase.

Regarding FR2-2, Qualcomm suggests to consider InH for FR2-2 as optional scenario, 7 companies [Samsung, Nokia, LG, Xiaomi, CATT, New H3C, Intel] suggest to deprioritize or not consider FR2-2 in Rel-18, with the following consideration:

* FR2-2 is defined for unlicensed technique [Xiaomi, LG]
* FR2-2 is not a target scenario in terms of latency, coverage and capacity [CATT, Samsung]
* FR2-2 has uncertain market rollout for the current moment [Nokia]

In addition, Qualcomm proposes to support HetNet with Urban Macro and Indoor as an optional deployment scenario for Deployment case 1 for FR1.

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

**SBFD Deployment Case 2**

There was a discussion in RAN1#109-e on the evaluation scenarios and priority for SBFD Deployment Case 2, but no consensus was achieved. In this meeting, companies’ views are still divergent. Several companies [Huawei, Samsung, Xiaomi, Spreadtrum, Docomo] suggest to deprioritize SBFD Deployment Case 2. Two companies [Nokia, Intel] suggest to reuse the scenarios agreed for Deployment Case 1 for Deployment Case 2. ZTE suggests a subset of the scenarios of Deployment case 1 for Deployment case 2. MediaTek suggests that no further prioritization between the deployment cases for SBFD is pursued in RAN1.

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

**SBFD Deployment Case 3**

For SBFD Deployment Case 3-1,

* Samsung suggests not to evaluate Indoor Hotspot/Office, Dense Urban (1-layer) and Urban Macro for as mandatory
* Intel suggests to reuse the scenarios agreed for SBFD Deployment Case 1
* The following scenarios are considered by some companies:
  + Urban Macro [ZTE (FR1), Xiaomi]
  + Dense Urban Macro layer [ZTE (FR2-1), Xiaomi]
  + Dense Urban Micro layer [ZTE(FR2-1)]

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

For SBFD Deployment Case 3-2,

* Ericsson suggests it can be done on a best effort basis.
* The following scenarios are considered by some companies:
  + HetNet with Urban Macro and Indoor office [Huawei (FR1), Nokia, CMCC (FR1)]
  + Dense Urban with 2-layer [ZTE (FR1), Xiaomi, CMCC (FR1)]

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

**SBFD Deployment Case 4**

There are few inputs on the scenarios for SBFD Deployment Case 4, and no company shows strong opinion to support Indoor hotspot and Dense Urban Micro layer.

### 1st Round Proposals

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

For NR duplex evolution evaluation, Rural scenario is not considered in Rel-18.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | We expect Rural CLI is not as challenging as than for Urban. Whatever schemes we come up with to manage CLI in Urban would be sufficient (or more than enough) for Rural. Hence, we agree with the proposal. |
| Intel | We are OK with FL’s proposal. The list of scenarios to simulate is already quite long, and we do not expect the rural scenario to bring any additional insights. |
| Spreadtrum | We agree with the proposal. |
| Ericsson | We support the proposal |
| New H3C | We are fine with the proposal |

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

For NR duplex evolution evaluation, FR2-2 is not considered in Rel-18.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | We are Ok with the proposal. Considerig the current workload in the SI, and additional consideration that RAN1 may need to discuss to enable operation in FR2-2, it may be indeed recommended to postpone enabling operation in FR2-2 to a later release or to resume discussion later on along this SI depending on progress. |
| Spreadtrum | We agree with the proposal. |
| Ericsson | We support the proposal |
| New H3C | We are fine with the proposal |

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

For SBFD evaluation from RAN1 perspective, the evaluation assumptions that are specific for Deployment Case 2 and Case 3-1 can be discussed with low priority (i.e., it can be discussed after the evaluation assumptions for Deployment case 1/4/3-2 are determined).

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Sony | Fine with the proposal. |
| Intel | We are generally OK to deprioritze some of the cases, and we believe that Case 4 and 3-2 should be also among them, considering that co-existence study was already performed in other release with similar assumptions RAN1 is taking for this SI, and also considering this type of evaluations have been handled in the past by RAN4 and are in RAN4’s domain of expertise. If we were to prioritize the agreed cases, our preference is as follows: case 1 > case 2/3-1 > case 4> case 3-2. |
| Spreadtrum | Considering the heavy workload of 4 deployment cases, we are OK to deprioritze case 2 and case3-1. |
| Ericsson | We support the proposal. |
| New H3C | We are fine with the proposal |

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

For evaluation of SBFD Deployment Case 3-2, consider the following scenarios for FR1:

* HetNet with Urban Macro and Indoor office
  + Urban Macro layer uses legacy static TDD operation, Indoor office layer uses SBFD operation
* (Optional) Dense Urban with 2-layer
  + Dense Urban Macro layer uses legacy static TDD operation, Dense Urban Micro layer uses SBFD operation

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | We are OK with the proposal, even though as indicated above it is our preference to deprioritize this case. |
| Spreadtrum | We agree with this proposal. It is a good way to evaluate SBFD performance in indoor scenario of case 1, and at the same time to make sure indoor office is practicable in the co-existence case in HetNet of case 3-2. |
| Ericsson | We cannot support this proposal in its current form. We need to have all the details about HetNets scenario before we can agree to this proposal. For example, what is the association method to be used including the cell-range extension? Is CoMP scenario deployed? Moreover, we think that the 2-layer scenario must be the same for both dynamic TDD and SBFD. However, Dense Urban with 2-layer has already been studied in the TR 38.828, therefore we think that could be the baseline. ***Initial proposal 1-1-4 (Modified by Ericsson):*** For evaluation of SBFD Deployment Case 3-2, consider the following scenarios for FR1:   * ~~(Optional)~~ Dense Urban with 2-layer   + Dense Urban Macro layer uses legacy static TDD operation, Dense Urban Micro layer uses SBFD operation * (Optional) HetNet with Urban Macro and Indoor office   + Urban Macro layer uses legacy static TDD operation, Indoor office layer uses SBFD operation   + FFS details on HetNets scenario, e.g., cell range extension, CoMP deployment scenario, number of users served by the small cells etc. |
| New H3C | We are fine with the proposal |

## Issue#1-2: Scenarios for dynamic/flexible TDD

### Submitted proposal

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| **Company** | **Proposals** |
| CMCC | FR1   * Indoor office * Urban Macro * HetNet with Urban Macro and Indoor office * Dense Urban with 2-layer   FR2-1   * Indoor office * Dense Urban Macro layer |
| Huawei | Although there is no agreement, most of the companies seem fine with the following proposal except the adjacent-channel coexistence case.   * FR1:   + High priority:     - Indoor office with dynamic/flexible TDD UL/DL assignment.     - HetNet with Urban Macro and Indoor Hotspot-office (InH-office) deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.       * Option 1: Indoor gNBs use UL dominant static TDD UL/DL configuration.       * Option 2: Indoor gNBs use dynamic/flexible TDD UL/DL assignment.     - FFS: Adjacent-channel coexistence case between dynamic/flexible TDD and legacy TDD.       * FFS: detailed scenario for adjacent-channel coexistence case.   + Optional:     - Urban Macro with dynamic/flexible TDD UL/DL assignment.     - Dense Urban with two layers deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.       * Option 1: Micro gNBs use UL dominant static TDD UL/DL configuration.       * Option 2: Micro gNBs use dynamic/flexible TDD UL/DL assignment. * FR2-1:   + Indoor office with dynamic/flexible TDD UL/DL assignment.   + Dense Urban Macro layer with dynamic/flexible TDD UL/DL assignment.   ***Proposal 9:*** *For dynamic/flexible TDD, HetNet with Urban Macro and indoor factory deployed in the same carrier should also be considered for FR1.*  ***Proposal 10:*** *Adjacent-channel coexistence case between dynamic/flexible TDD and legacy TDD can be studied and the detailed simulation assumptions should be determined.*  The adjacent-channel coexistence case between dynamic/flexible TDD and legacy TDD has been studied by RAN4 in Rel-16. Thus, one should try to avoid repeating the work in Rel-18 in RAN1. The detailed simulation assumptions that are different from the Rel-16 co-existence study should be determined. |
| ZTE | ***Proposal 5:*** *For evaluation of dynamic/flexible TDD, consider the following scenarios for evaluation:*   * *FR1*   + *Indoor office with dynamic TDD UL/DL assignment*   + *HetNet with Urban Macro and Indoor office deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.*     - *Option 1: Indoor gNBs use UL dominant static TDD UL/DL configuration*     - *Option 2: Indoor gNBs use dynamic TDD UL/DL assignment*   + *Adjacent-channel coexistence case between dynamic TDD and legacy TDD*     - *FFS: detailed scenario for adjacent-channel coexistence case*   + *Urban Macro with dynamic TDD UL/DL assignment*   + *Dense Urban with two layers deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.*     - *Option 1: Micro gNBs use UL dominant static TDD UL/DL configuration*     - *Option 2: Micro gNBs use dynamic TDD UL/DL assignment* * *FR2-1*   + *Indoor office with dynamic TDD UL/DL assignment*   + *Dense Urban Macro layer with dynamic TDD UL/DL assignment* |
| Qualcomm | ***Proposal 30***: For FR1, support the following deployment scenarios for study on potential enhancement on Dynamic/flexible TDD.   * Baseline: UMa. * HetNet (Urban Macro and Indoor office)   ***Proposal 31***: 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) |
| vivo | ***Proposal 6:*** *For evaluation of dynamic/flexible TDD, consider the following scenarios for evaluation:*   * *Indoor office with TDD UL/DL configuration that can be updated per [X] slot(s).*    + *where X≥1, and can be reported by companies.* * *HetNet with Urban Macro and Indoor office deployed in the same carrier or adjacent carriers, where Macro gNBs use DL dominant semi-static TDD UL/DL configuration and Indoor gNBs use dynamic TDD UL/DL assignment.* |
| CATT | ***Proposal 2***: The deployment scenarios for dynamic/flexible TDD evaluation at least include indoor office and heterogeneous deployment with Urban Macro and Indoor office.   * Indoor office with dynamic TDD UL/DL assignment * HetNet with Urban Macro and Indoor office deployed in the same carrier   + Macro layer use DL dominant static TDD UL/DL configuration: {DDDSU}   + Indoor layer use UL dominant static TDD UL/DL configuration: {DSUUU} |
| Nokia, Nokia Shanghai Bell | **Observation 1:** Companies’ preferences on the deployment scenarios for Rel-18 dynamic TDD are well aligned with the deployment scenarios adopted during Rel-16 coexistence studies.  ***Proposal 1***: Unless significant changes on the parameters/assumptions from the previous Rel-16 adjacent coexistence studies are agreed, the previous conclusions remain valid and there is no need to perform new coexistence studies.  ***Proposal 2:*** For evaluation of dynamic/flexible TDD, consider at least the following co-channel scenarios for FR1:   * + Indoor office with dynamic TDD UL/DL assignment   + HetNet with Urban Macro and Indoor office deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.     - Option 1: Indoor gNBs use UL dominant static TDD UL/DL configuration     - Option 2: Indoor gNBs use dynamic TDD UL/DL assignment |
| MediaTek | ***Proposal 2***: For the evaluations of DTDD schemes, RAN1 should consider the deployment scenarios listed in Table 1.  Table 1: 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% | |
| Xiaomi | ***Proposal 8:*** For flexible/dynamic TDD, evaluate and study the performance in HetNet scenario. |
| Intel | ***Proposal 4:*** For flexible/dynamic TDD, at least the following scenarios are considered for evaluation:   * FR1:   + Indoor office with dynamic TDD UL/DL assignment   + Urban Macro with dynamic TDD UL/DL assignment   + Optional: Dense Urban with two layers deployed in the same carrier, where macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario:     - * Option 1: Micro gNBs use UL dominant static TDD UL/DL configuration       * Option 2: Micro gNBs use dynamic TDD UL/DL assignment * FR2-1:   + Indoor office with dynamic TDD UL/DL assignment   + Dense Urban Macro layer with dynamic TDD UL/DL assignment |
| Dell | ***Observation 1:*** As per the conclusions of the Rel-16 dynamic TDD study on cross-link interference (CLI) [TR 38.828], the feasibility of the dynamic TDD in FR1 Macro deployments is challenging due to severe gNB-to-gNB CLI. Therefore, FR1 dynamic TDD is most feasible within low transmit power deployments, e.g., small cell deployments.  ***Observation 2:*** Dynamic TDD Macro deployments over FR2 are more feasible due to the higher path-loss and the beam-forming isolation, resulting in a controlled gNB-to-gNB CLI.  ***Proposal 1:*** To avoid repetition of Rel-16 dynamic TDD study simulation activities, evaluations of NR full duplex consider indoor/small cell/indoor hot-spot deployments over FR1. For FR2, dense urban, urban macro, and indoor hotspot deployments are considered. |
| OPPO | ***Proposal 3:*** For dynamic/flexible TDD evaluation, define one non-coexistence deployment case and one coexistence deployment case, each of which runs on single carrier and assumes the same TDD-UL-DL-ConfigCommon across all cells. |

### Summary

In RAN1#109-e meeting, there was a discussion on deployment Scenarios for dynamic/flexible TDD. Although there is no agreement, most of the companies seem fine with the following proposal except the adjacent-channel coexistence case.

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| **Updated proposal 2-1c:**  For evaluation of dynamic/flexible TDD, consider the following scenarios for evaluation:   * FR1   + High priority     - Indoor office with dynamic TDD UL/DL assignment     - HetNet with Urban Macro and Indoor office deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.       * Option 1: Indoor gNBs use UL dominant static TDD UL/DL configuration       * Option 2: Indoor gNBs use dynamic TDD UL/DL assignment     - FFS: Adjacent-channel coexistence case between dynamic TDD and legacy TDD       * FFS: detailed scenario for adjacent-channel coexistence case   + Optional:     - Urban Macro with dynamic TDD UL/DL assignment     - Dense Urban with two layers deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.       * Option 1: Micro gNBs use UL dominant static TDD UL/DL configuration       * Option 2: Micro gNBs use dynamic TDD UL/DL assignment * FR2-1   + Indoor office with dynamic TDD UL/DL assignment   + Dense Urban Macro layer with dynamic TDD UL/DL assignment |

In RAN#110, the preference on the scenarios for single operator case are summarized as following.

* FR1
  + Indoor office [Huawei, ZTE, vivo, CATT, Nokia, Intel, Dell, CMCC]
  + HetNet with Urban Macro and Indoor office [Huawei, ZTE, Qualcomm, vivo, CATT, Nokia, Xiaomi, CMCC]
  + (Optional) Urban Macro [Huawei (optional), ZTE, Qualcomm, Intel, CMCC]
  + (Optional) Dense Urban with two layers [Huawei (optional), ZTE, Intel (optional), CMCC]
* FR2-1
  + Indoor office [Huawei, ZTE, Qualcomm (optional), Intel, Dell, CMCC]
  + Dense Urban Macro layer [Huawei, ZTE, Intel, CMCC]

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

Regarding the adjacent-channel coexistence case between dynamic TDD and legacy TDD for FR1, few companies have inputs, and companies’ views are still divergent.

* 3 companies [Huawei, Nokia, Dell] suggest to avoid repeating the Rel-16 co-existence study in Rel-18 in RAN1. They think unless significant changes on the parameters/assumptions from the previous Rel-16 adjacent coexistence studies are agreed, the previous conclusions remain valid and there is no need to perform new coexistence studies.
* MediaTek suggests several scenarios including Urban Macro and Indoor office, and vivo suggests HetNet with Urban Macro and Indoor office on adjacent carriers.

In Moderator’s view, companies who support evaluation scenarios for adjacent-channel coexistence case should explain more on the difference (e.g., the detailed simulation assumptions) from the Rel-16 co-existence study.

### 1st Round Proposals

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

For evaluation of dynamic/flexible TDD for the single operator case, consider the following scenarios:

* FR1
  + Indoor office with dynamic TDD UL/DL assignment
  + HetNet with Urban Macro and Indoor office deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.
    - Option 1: Indoor gNBs use UL dominant static TDD UL/DL configuration
    - Option 2: Indoor gNBs use dynamic TDD UL/DL assignment
  + (Optional) Urban Macro with dynamic TDD UL/DL assignment
  + (Optional) Dense Urban with two layers deployed in the same carrier, and Macro gNBs use DL dominant static TDD UL/DL configuration. Both of the following options can be considered for this scenario.
    - Option 1: Micro gNBs use UL dominant static TDD UL/DL configuration
    - Option 2: Micro gNBs use dynamic TDD UL/DL assignment
* FR2-1
  + Indoor office with dynamic TDD UL/DL assignment
  + Dense Urban Macro layer with dynamic TDD UL/DL assignment
* For above scenarios, the following is assumed:
  + DL dominant static TDD UL/DL configuration: assume {DDDSU}, where S=[12D:2G:0U]
  + UL dominant static TDD UL/DL configuration: assume {DSUUU}, where S=[12D:2G:0U]
  + dynamic TDD UL/DL assignment: assume {FFFFF}, companies to report the guard symbols assumed in their simulation

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | Fine with the proposal. |
| Intel | For FR-1, while we’re open to considering HetNet scenarios (e.g., UMa + Hotspot) and see their value, we think that Urban macro should form the baseline scenarios, similar to SBFD. |
| Spreadtrum | Support in principle. But for Urban Macro, it was recommended not to be considered in R16 adjacent channel coexistence study. And compared with R18, the simulation assumption of dynamic TDD in R16 is a little optimistic only considering 0% grid shift. We suggest to avoid repetition work and remove Urban Macro in FR1. |
| Ericsson | Support in principle but we think that case 3-2 needs to be aligned between SBFD and dynamic TDD scenarios. |
| New H3C | We are fine with the proposal |

## Issue#1-3: Others

### Submitted proposal

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| **Company** | **Proposals** |
| ZTE | ***Proposal 1****: For Rel-18 duplex evolution SI,*   * *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.* * *Perform thorough analysis and study for dynamic/flexible TDD with the same priority as sub-band non-overlapping duplex.*   ***Proposal 2****:* *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.* |
| InterDigital | ***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.* |
| Charter Communications | ***Observation 1:*** AMBIT, CBRS and C bands will suffer from CLI from each other as there is no guard band between them. This CLI will affect gNBs as well as UEs in these three networks.  ***Observation 2:*** The permitted frequency placement of SBFD deployment(s) and the flexibility of dynamically switching TDD configurations within these sub-bands impact the CLI caused to legacy networks.  ***Proposal 1:*** For mitigation of CLI, it is desirable to not place full-duplex sub-bands at the edge of a conventional TDD band especially in the bands with no guard bands such as N77. |
|  |  |

# Issue#2: SLS Evaluation Methodology

## Issue#2-1: Interference modelling for SBFD

### Submitted proposal

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| **Company** | **Proposals** |
| CMCC | **Inter-site gNB-gNB co-channel inter-subband CLI**  ***Proposal 9****: For inter-site gNB-gNB co-channel inter-subband CLI modelling in SLS,*   * *The interference due to Aspect 1 (i.e. the unwanted emissions due to Tx non-linearity at the transmitter of the aggressor from the allocated RBs to the non-allocated RBs in the same carrier) can be modelled as white noise at the aggressor gNB side.* * *The interference due to Aspect 2 (i.e. the receiver selectivity at the victim to receive the desired signal in the allocated RBs in the presence of the unwanted signals at the non-allocated RBs) can be modelled as white noise at the victim gNB side.*     Figure 4 Inter-site gNB-gNB co-channel inter-subband CLI.  **Co-site inter-sector co-channel inter-subband CLI**  ***Proposal 10****: For co-site inter-sector co-channel inter-subband CLI modelling in SLS, it can be modelled as white noise at the victim BS side, using the similar method of gNB self-interference modelling. As one example, the co-site inter-sector co-channel inter-subband CLI from a neighbouring sector on a single receiver chain at UL RB n can be modelled as*   * *, wherein,*   + *is the DL transmission power of the neighbouring sector across all transmit chains at RB m (in dBm).*   + *is* *co-site inter-sector interference ratio. The value of can be a few dBs higher than the RSI value for self-interference.*   **UE-UE co-channel inter-subband CLI**  ***Proposal 11****: In SLS, UE-UE co-channel inter-subband CLI can be modelled as a white noise at the victim UE side. As one example, the UE-UE co-channel inter-subband CLI from aggressor UE to victim UE B on a single receiver chain at DL RB n can be modelled as*   * *, wherein,*   + *m is the UL RB index of aggressor UE .*   + *is the UL transmission power of aggressor UE across all transmit chains at RB m (in dBm).*   + *is the coupling loss between the aggressor UE and the victim UE .*   + *is the UE-UE per-RB inter-subband interference ratio (ISIR) which can be derived based on Aspect 1 and Aspect 2 as below*   *wherein,*   * *is UE-UE inter-subband Tx Leakage power ratio (ISLR), which is defined as the ratio of the Tx power centered on an allocated RB m to the unwanted leakage power centered on a non-allocated RB n in the same carrier.* * *is UE-UE inter-subband Rx selectivity (ISS), which is defined as the ratio of the OTA interference power centered on a non-allocated RB m to the unwanted Rx power centered on an allocated RB n in the same carrier.* |
| Huawei | **gNB self-interference modelling**  ***Proposal 11:*** *The gNB self-interference can be modeled as white Gaussian noise as follows:*   * *The gNB self-interference across all Rx chains at UL frequency unit can be modeled as*   *where,*   * + *is the number of Rx chains at gNB,*   + *, ,*   + *is the power of gNB self-interference on each Rx chain at UL frequency unit ,*   + *is the DL power transmitted by gNB across all Tx chains at DL frequency unit .* * *The covariance of gNB self-interference across all Rx chains at UL frequency unit can be modeled as .*   **Inter-site gNB-gNB co-channel inter-subband CLI modelling**  ***Proposal 12:*** *The inter-site gNB-gNB co-channel inter-subband CLI can be modeled as follows:*   * *Introduce a co-channel inter-subband leakage power ratio (ISLR) to represent the co-channel inter-subband leakage power suppression capability at gNB of aggressor.*   + *The ISLR, denoted as , can be defined as the ratio of the transmission power centered on an allocated frequency unit in a SBFD carrier to the leakage power centered on non-allocated frequency unit in the same SBFD carrier.* * *Introduce a co-channel inter-subband selectivity (ISS) to represent the co-channel inter-subband selectivity capability at gNB of victim.*   + *The ISS, denoted as , can be defined as the ratio of the receive power centered on allocated frequency unit in a SBFD carrier to the residual power suppressed by receiver selectivity centered on non-allocated frequency unit in the same SBFD carrier.* * *The inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit at gNB of victim can be modeled as*   *where,*   * *is the first part of inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit , caused by power leakage at gNB of aggressor,*   + *is the channel between gNB of aggressor and gNB of victim at UL frequency unit ,*   + *is unwanted emissions across all Tx chains at UL frequency unit at gNB of aggressor,*     - *is the number of Tx chains at gNB of aggressor,*     - *, , is modelled as white Gaussian noise,*     - *is the leakage power on each Tx chain at UL frequency unit at gNB of aggressor,*     - *is the DL power transmitted across all Tx chains at DL frequency unit at gNB of aggressor,* * *is the second part of inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit , caused by receiver selectivity at gNB of victim,*   + *is the channel between gNB of aggressor and gNB of victim at DL frequency unit ,*   + *is the precoder at DL frequency unit at gNB of aggressor, ,*   + *is the symbol transmitted at DL frequency unit at the gNB of aggressor.* * *The covariance of inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit can be modeled as*   *where,*   * *,*   + *is the number of Rx chains at gNB of victim,*   + *is DL transmission power across all Tx chains at DL frequency unit at gNB of aggressor.*   **Co-site inter-sector gNB-gNB co-channel inter-subband CLI modelling**  ***Proposal 13:*** *The co-site inter-sector gNB-gNB co-channel inter-subband CLI can be modeled as white Gaussian noise as follows:*   * *The co-site inter-sector gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit at gNB of victim can be modeled as*   *where,*   * + *is the number of Rx chains at gNB of victim,*   + *, ,*   + *is the power of co-site inter-sector gNB-gNB co-channel inter-subband CLI on each Rx chain at UL frequency unit at gNB of victim,*   + *is the DL power transmitted by gNB of aggressor across all Tx chains at DL frequency unit .* * *The covariance of co-site inter-sector gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit can be modeled as .*   **UE-UE co-channel inter-subband CLI modelling**  ***Proposal 14:*** *The UE-UE co-channel inter-subband CLI can be modeled as white Gaussian noise as follows:*   * *Introduce a new parameter, referred as co-channel inter-subband interference ratio (ISIR), to represent both of ISLR and ISS together, which is defined as follows:*   *where,*   * *.* * *The UE-UE co-channel inter-subband CLI across all Rx chains at DL frequency unit at UE of victim can be modeled as*   *where,*   * + *is the number of Rx chains at UE of victim,*   + *, ,*   + *is the power of UE-UE co-channel inter-subband CLI on each Rx chain at DL frequency unit at UE of victim,*   + *is the total UL power transmitted by UE of aggressor across all Tx chains,*   + *is the number of frequency units within DL subband.* * *The covariance of UE-UE co-channel inter-subband CLI across all Rx chains at UL frequency unit can be modeled as .*   **Inter-site gNB-gNB adjacent-channel CLI modelling**  ***Proposal 15:*** *The inter-site gNB-gNB adjacent-channel CLI can be modeled as inter-site gNB-gNB co-channel inter-subband CLI by replacing and with and , respectively, where,*   * *Adjacent-channel inter-subband leakage power ratio, denoted as , is defined as the ratio of the transmission power centered on allocated frequency unit in a SBFD carrier to the leakage power centered on non-allocated frequency unit in the adjacent SBFD carrier.* * *Adjacent-channel inter-subband selectivity, denoted as , is defined as the ratio of the receive power centered on allocated frequency unit in a SBFD carrier to the residual power suppressed by receiver selectivity centered on non-allocated frequency unit in the adjacent SBFD carrier.*   **Co-site gNB-gNB adjacent-channel CLI modelling**  ***Proposal 16:*** *The co-site gNB-gNB adjacent-channel CLI can be modeled as co-site inter-sector gNB-gNB co-channel inter-subband CLI by replacing with* *, where,*   * *Ratio of co-site adjacent-channel CLI (RCOSITE-AC), denoted as , is defined as the ratio of the total power transmitted by a gNB of aggressor across all Tx chains on a frequency unit in a SBFD carrier to the residual interference received by a gNB of victim on a single Rx chain at a different frequency unit in the adjacent SBFD carrier.*   **UE-UE adjacent-channel CLI modelling**  ***Proposal 17:*** *The UE-UE adjacent-channel CLI can be modeled as UE-UE co-channel inter-subband CLI by replacing ISIR with ACIR.* |
| ZTE | ***Proposal 7****: Use the following interference model for subband full duplex simulation as the starting point.*   * *gNB-gNB co-channel intra-subband interference per RB of this intra-subband per aggressor gNB*      * *UE-UE co-channel intra-subband interference per RB of this intra-subband per aggressor UE*      * *Other interference models described in Appendix 8.2 can be used as the starting point for SLS calibration.* |
| Ericsson | ***Proposal 22:*** 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.  ***Proposal 23:*** Considering there is no RAN4 requirement on inter-sub-band 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 selectivity requirement. |
| 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 20***: 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.   ***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 21:*** 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 22:*** 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.  **Inter-gNB inter-subband CLI model**  ***Observation 13:*** RAN1 needs to agree on the inter-subband cross-link interference model for subband full duplex evaluation.  ***Observation 15:*** The DL non-linearity caused by IMDs may have some directionality depending on the number of DL spatial beams.  ***Observation 16:*** It is important to consider both large-scale and small-scale fading’s when modelling the inter-gNB channel and CLI to get accurate modelling of the spatial beamforming gains or nulls.  ***Proposal 24:***­ For the modelling of inter-gNB channel and CLI, consider both large-scale and small-scale for both component of the DL-Tx and DL-NL.   * For DL-Tx, first apply large-scale and small scale of DL-Tx and aspect 2 (Rx selectivity) * For DL-NL, first apply Aspect 1 (Tx leakage ratio) and then apply both large-scale and small-scale fading.   **Inter-UE inter-subband CLI modelling**  ***Proposal 26***:­ For the modelling of inter-UE channel and CLI, consider both large-scale and small-scale for both component of the UL-Tx and only large-scale fading for Tx-NL.   * For UL-Tx, first apply large-scale and small scale of DL-Tx and then aspect 2 (Rx selectivity if any). * For UL-NL, first apply Aspect 1 (Tx leakage ratio) and then large-scale fading (FFS: small scale fading) |
| Spreadtrum, BUPT | ***Proposal 9:*** SIR/ISIR with a coarser granularity, e.g., per carrier/subband can be used in SINR calibration before the feedback from RAN4. |
| Xiaomi | ***Observation 2:*** For deployment case 2, the following two interference type should be take into account:   * gNB-UE co-channel inter-subband interference: Interfernece caused by DL transmission of the aggressor gNB on a first set of RBs in a carrier to DL reception of the victim UE on a second set of RBs in the same carrier, where the two RB sets are non-overlapping in frequency. * UE-gNB co-channel inter-subband interference: Interfernece caused by UL transmission of the aggressor UE on a first set of RBs in a carrier to UL reception of the victim gNB on a second set of RBs in the same carrier, where the two RB sets are non-overlapping in frequency. |
| Dell | ***Proposal 2:*** Discuss and agree on SBFD evaluation scenarios which specifically show the downlink and uplink performance impact of the new SBFD-specific interference types. |
| Kumu | ***Observation 4:*** The amount of residual self-interference depends on gNB spatial isolation, subband frequency isolation, RF interference cancellation, digital interference cancellation and beamform nulling/isolation.  ***Proposal 4:*** The residual self-interference at gNB receiver is modelled as fixed value across the UL subband and is given by  where   1. αL is the overall self-inference reduction capability of the gNB by means of spatial isolation, subband frequency isolation, 2. αRFX is the RF layer interference cancellation including beam nulling and explicit RF cancellation taps. 3. α0 being other losses or techniques that reduces self interference. |
|  |  |

### Summary

Regarding gNB self-interference modelling in SLS, moderator suggests **Initial proposal 2-1-1** based on the submitted proposals.

Regarding inter-site gNB-gNB co-channel inter-subband CLI modelling in SLS, moderator suggests **Initial proposal 2-1-2** based on the submitted proposals.

Regarding co-site inter-sector co-channel inter-subband CLI modelling in SLS, moderator suggests **Initial proposal 2-1-3** based on the submitted proposals.

Regarding UE-UE co-channel inter-subband CLI modelling in SLS, moderator suggests **Initial proposal 2-1-4** based on the submitted proposals.

Regarding inter-site gNB-gNB adjacent-channel CLI modelling, co-site gNB-gNB adjacent-channel CLI modelling and UE-UE adjacent-channel CLI modelling, they can be discussed later after we make some conclusions for above proposals.

In addition, regarding RSI value the following values are used by companies in their simulations.

* 135 dB [Qualcomm]
  + Spatial isolation plus Digital NLIC = 90 dB, Frequency isolation: 45 dBc/20MHz
* 137 dB [Ericsson]
  + Antenna isolation = 80 dB, Digital cancellation: 15 dB, Inter-subband leakage ratio (ACIR): 42dB
* 120dB [ZTE]
* 110dB [vivo]
  + Spatial isolation = 65 dB, Frequency isolation: 45 dB
* 123dB [LG]
  + ASIR: 43 dB + SIC: 80dB
* Opt 1: 105dB; Opt 2: 130dB [Spreadtrum]
* 128dB (85dB+43dB) or 143 dB (100dB+43dB) [Xiaomi]

### 1st Round Proposals

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

*The* *gNB self-interference can be modeled as white Gaussian noise in SLS as follows:*

* *The gNB self-interference across all Rx chains at UL frequency unit can be modeled as*

*where,*

* + *is the number of Rx chains at gNB,*
  + *, ,*
  + *is the power of gNB self-interference on each Rx chain at UL frequency unit ,*
  + *is the DL power transmitted by gNB across all Tx chains at DL frequency unit ,*
  + *is the ratio of self-interference (RSI).*
* *The covariance of gNB self-interference across all Rx chains at UL frequency unit can be modeled as .*

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | For this topic, since during prior RAN1 meeting we have sent an LS to RAN4 inquiring for their help regarding the self-interference modelling, we may prefer to postpone discussion until we receive an answer from them. |
| Spreadtrum | Agree with Intel, but we also suggest to use a simplified interference modeling (ACLR liked) for calibration before feedback from RAN4. |
| Ericsson | We agree with Intel and also Spreadtrum that a simple model is required for modeling self-interference in SLS. |
| New H3C | We hope to simplify this interference modeling. |

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

*The inter-site gNB-gNB co-channel inter-subband CLI can be modeled as follows in SLS:*

* *Introduce a BS co-channel inter-subband leakage power ratio (ISLR) to represent the co-channel inter-subband leakage power suppression capability at aggressor gNB.*
  + *The BS ISLR, denoted as , can be defined as the ratio of the transmission power centered on an allocated frequency unit in a SBFD carrier to the leakage power centered on a non-allocated frequency unit in the same SBFD carrier.*
* *Introduce a BS co-channel inter-subband selectivity (ISS) to represent the co-channel inter-subband selectivity capability at victim gNB.*
  + *The BS ISS, denoted as , can be defined as the ratio of the receive power centered on a non-allocated frequency unit in a SBFD carrier to the residual power suppressed by receiver selectivity centered on an allocated frequency unit in the same SBFD carrier.*
* *The inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit at victim gNB can be modeled as*

*where,*

* *is the first part of inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit , caused by power leakage at aggressor gNB,*
  + *is the channel between aggressor gNB and victim gNB at UL frequency unit , the analog beamforming at the aggressor gNB and victim gNB can be taken into account by* ,
  + *is the unwanted emissions across all Tx chains at UL frequency unit at aggressor gNB,*
    - *is the number of Tx chains at aggressor gNB,*
    - *, , is modelled as white Gaussian noise,*
    - *is the leakage power on each Tx chain at UL frequency unit at aggressor gNB,*
    - *is the DL power transmitted across all Tx chains at DL frequency unit at aggressor gNB,*
* *is the second part of inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit , caused by receiver selectivity at victim gNB,*
  + *is the channel between aggressor gNB and victim gNB at DL frequency unit , the analog beamforming at the aggressor gNB and victim gNB can be taken into account by* ,
  + *is the digital precoder at DL frequency unit at aggressor gNB, ,*
  + *is the symbol transmitted at DL frequency unit at aggressor gNB.*
* *The covariance of inter-site gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit can be modeled as*

*where,*

* *,*
  + *is DL transmission power across all Tx chains at DL frequency unit at aggressor gNB.*

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| Sony | Are we supposed to get RAN4 input on this? Is the intention here is for RAN4 to define only *βISLR,BS* and *βISS,BS*? |
| Intel | Similarly as prior proposal, we may prefer to postpone discussion until RAN1 receives an answer from RAN4 regading this topic. It may not be proper to agree on a specific model, while RAN1 is expecting input from RAN4. |
| Spreadtrum | Same as proposal 2-1-1. |
| Ericsson | Same as proposal 2-1-1. |
| New H3C | we hope to simplify this interference modeling. |

#### ***Initial proposal 2-1-3:***

*The* *co-site inter-sector co-channel inter-subband CLI can be modeled as white Gaussian noise in SLS as follows:*

* *Similar method for gNB self-interference modelling can be used for co-site inter-sector co-channel inter-subband CLI modelling.*
* *A new parameter, i.e., ratio of co-site inter-sector co-channel inter-subband CLI (RCOSITE), is introduced to represent the co-site inter-sector co-channel inter-subband CLI suppression capability of gNB. The RCOSITE, denoted as , can be defined as the ratio of the total power transmitted by aggressor gNB across all Tx chains on a frequency unit in a SBFD carrier to the residual interference received by victim gNB on a single Rx chain at a different frequency unit in the same SBFD carrier, where the aggressor gNB and the victim gNB are from different sectors of the same site.*
* *The co-site inter-sector co-channel inter-subband CLI across all Rx chains at UL frequency unit at victim gNB can be modeled as*

*where,*

* + *is the number of Rx chains at victim gNB,*
  + *, ,*
  + *is the power of co-site inter-sector co-channel inter-subband CLI on each Rx chain at UL frequency unit at victim gNB,*
  + *is the DL power transmitted by aggressor gNB across all Tx chains at DL frequency unit .*
* *The covariance of co-site inter-sector gNB-gNB co-channel inter-subband CLI across all Rx chains at UL frequency unit can be modeled as .*

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | Same as above. |
| Spreadtrum | Same as proposal 2-1-1. |
| Ericsson | Same as proposal 2-1-1. |
| New H3C | we hope to simplify this interference modeling. |

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

*The UE-UE co-channel inter-subband CLI can be modeled as white Gaussian noise in SLS as follows:*

* *Introduce a UE co-channel inter-subband leakage power ratio (ISLR) to represent the co-channel inter-subband leakage power suppression capability at aggressor UE.*
  + *The UE ISLR, denoted as , can be defined as the ratio of the transmission power centered on an allocated frequency unit in a SBFD carrier to the leakage power centered on a non-allocated frequency unit in the same SBFD carrier.*
* *Introduce a UE co-channel inter-subband selectivity (ISS) to represent the co-channel inter-subband selectivity capability at victim UE.*
  + *The UE ISS, denoted as , can be defined as the ratio of the receive power centered on a non-allocated frequency unit in a SBFD carrier to the residual power suppressed by receiver selectivity centered on an allocated frequency unit in the same SBFD carrier.*
* *Introduce a UE-UE co-channel inter-subband interference ratio (ISIR) to represent both of ISLR and ISS together, which is defined as follows:*
* *The UE-UE co-channel inter-subband CLI across all Rx chains at DL frequency unit at victim UE can be modeled as*

*where,*

* + *is the number of Rx chains at victim UE,*
  + *, ,*
  + *is the power of UE-UE co-channel inter-subband CLI on each Rx chain at DL frequency unit at UE of victim,*
  + *is the coupling loss (linear value) between the aggressor UE and the victim UE,*
  + *is the UL transmission power of aggressor UE across all Tx chains at UL frequency unit .*
* *The covariance of UE-UE co-channel inter-subband CLI across all Rx chains at DL frequency unit can be modeled as .*

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | Same comment on whether this should be defined by RAN4 or is RAN4’s task is only to define *βISLR,UE* and *βISS,UE*? |
| Intel | Same as above. |
| Spreadtrum | Same as proposal 2-1-1. |
| Ericsson | Same as proposal 2-1-1. |
| New H3C | we hope to simplify this interference modeling. |

## Issue#2-2: Performance metrics

### Submitted proposal

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| **Company** | **Proposals** |
| CMCC | **For SBFD**  *Definition of UPT*  ***Proposal 12****: For UPT related performance metrics in SLS, use the following definition.*   * *UPT: For FTP model 3, user perceived throughput (during active time), is defined as the size of an FTP packet divided by the time which starts when the packet is received in the transmit buffer and ends when the last bit of the packet is correctly delivered to the receiver.*   + *Average-UPT of a user: defined as the average from all UPTs for all FTP packets intended for this user.*   + *Tail-UPT of a user: defined as the worst 5% UPT among all packets intended for a user.*   + *Unfinished FTP packets should be incorporated in the UPT calculation. The number of served bits (possibly zero) of an unfinished FTP packet by the end of the simulation is divided by the served time (simulation end time – file arrival time).* * *Average-UPT CDF: The CDF of the average UPTs for all users.* * *Tail-UPT CDF: The CDF of the tail UPTs for all users.* * *Mean/5%/50%/95% of Average-UPT: The mean/5%/50%/95% value of average UPTs for all users.* * *Mean/5%/50%/95% of Tail-UPT: The mean/5%/50%/95% value of tail UPTs for all users.*   *Definition of latency*  ***Proposal 13****: For latency related performance metric in SLS, use the following definition.*   * *Packet latency: defined as the time which starts when the packet is received in the transmit buffer and ends when the last bit of the packet is correctly delivered to the receiver.* * *UE average latency: defined as the average packet latency for a UE* * *UE average latency CDF: The CDF of the UE average latency for all users.* * *Mean/5%/50%/95% of UE average latency: The mean/5%/50%/95% value of UE average latency for all users.*   *Definition of resource utilization*  ***Proposal 14****: Two types of RU (Resource utilization) are defined for SBFD evaluation.*   * *Type-1 RU: DL/UL Type-1 RU = Number of RB per cell used by traffic for the given link direction during observation time / Total number of RB per cell including DL, UL and guard band over observation time.* * *Type-2 RU (Follow TR 36.814): DL/UL Type-2 RU = Number of RB per cell used by traffic for the given link direction during observation time / Total number of RB per cell available for traffic for the given link direction over observation time* * *Note: In case of MU-MIMO, one RB allocated to N users within a cell is only counted as used once.*   *Definition of DL/UL received SINR*  ***Proposal 16****: For DL/UL received SINR using SLS, the following metrics can be considered.*   * *Metric 1: CDF of coupling loss from Tx antenna port 0 of gNB (serving cell) to Rx antenna port 0 of UE* * *Metric 2: CDF of legacy DL wideband pre-processing SINR considering legacy gNB-UE interference only* * *Metric 3: CDF of SBFD DL pre-processing SINR considering legacy gNB-UE interference and UE-UE co-channel inter-subband CLI* * *Metric 4: CDF of legacy UL pre-processing SINR considering legacy UE-gNB interference only* * *Metric 5: CDF of SBFD UL pre-processing SINR considering legacy UE-gNB interference, self-interference and gNB-gNB co-channel inter-subband CLI*   **For dynamic/flexible TDD**  ***Proposal 32****: For evaluation methodologies for dynamic/flexible TDD, resue SBFD as much as possible, e.g.,*   * *Performance metrics used for evaluation of SBFD can also be used for evaluation of dynamic/flexible TDD except the SBFD-specific metrics.*   ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.* |
| Huawei | **Definition of UPT**  ***Proposal 26:*** *Adopt the following definition of UPT for evaluation on Rel-18 NR duplex operation.*   * *For FTP model 3, user perceived throughput (during active time), is defined as the size of a FTP packet divided by the time between the arrival of the FTP packet and the reception of the last bit of the FTP packet.*   **Definition of latency**  ***Proposal 27:*** *Adopt the following definition of latency for evaluation on Rel-18 NR duplex operation.*   * *DL packet latency is defined as the time between the arrival of the DL FTP packet at gNB side and the correct decoding of the DL FTP packet at UE side.* * *UL packet latency is defined as the time between the arrival of the UL FTP packet at UE side and the correct decoding of the UL FTP packet at gNB side.* * *Note: HARQ re-transmission should be considered for latency evaluation.*   **Definition of resource utilization**  ***Proposal 28:*** *Adopt the following definition of resource utilization for evaluation on Rel-18 NR duplex operation.*   * *Resource utilization = Number of RB per cell used by traffic during observation time / Total number of RB per cell available for traffic over observation time.* * *In case of MU-MIMO, one RB allocated to users within a cell is counted as used once.*   **Others**  ***Proposal 29:*** *The blocking interference of gNB suffered by other gNBs should be evaluated in system level simulation with the definition provided as follows:*  *where,*   * *is the blocking of gNB suffered by all other gNB on each Rx chain.* * *is the blocking from gNB to gNB on each Rx chain.*   + *is the total DL transmit power across all Tx chains at gNB .*   + *is the channel between gNB to gNB at DL frequency unit .*   + *is the precoder at gNB at DL frequency unit , except for*  *in the case of that the DL frequency unit is not scheduled.*   + *is the number of Rx chains for gNB .* |
| ZTE | **Definition of UPT**  ***Proposal 10****: Regarding the DL/UL UPT or user throughput (CDF or {mean, 5%, 50%, 95%}) using SLS for SBFD and dynamic/flexible TDD evaluation, clarify the following issues.*   * *Alt.1: {amount of data (file size)* ***for all the packets generated by one UE****} divided by {time needed to download data starts when the* ***first*** *packet is received in the transmit buffer, and ends when the last bit of the* ***last*** *packet is correctly delivered to the receiver}* * *Alt.2: Calculate the user throughput for each packet, i.e., {amount of data (file size)* ***for each packet for one UE****} divided by {time needed to download data starts when the* ***each corresponding*** *packet is received in the transmit buffer, and ends when the last bit of the* ***corresponding*** *packet is correctly delivered to the receiver}* * *Alt.2-1: Calculate the average user throughput for each UE and get one CDF for the average user throughput;* * *Alt.2-2: Generate the CDF for each packet of each UE.*   *FFS how to count/consider the packets that are not correctly delivered to the receiver (e.g., due to interference).*  **Definition of latency**  ***Proposal 11****: Clarify the performance metric for SBFD and dynamic/flexible TDD evaluation as following:*   * *Latency (CDF or {mean, 5%, 50%, 95%}) using SLS: time needed to download data starts when the packet is received in the transmit buffer, and ends when the last bit of the packet is correctly delivered to the receiver*   + *Alt.1: Calculate the latency for each packet for each UE, and then calculate the average latency for each UE, then generate the CDF for these average latency for each UE;*   + *Alt.2: Calculate the latency for each packet for each UE, and then generate CDF of latency for all these packets from all the UEs.*   **Definition of resource utilization & DL/UL received SINR**  ***Proposal 12****: Clarify the performance metric for SBFD and dynamic/flexible TDD evaluation as following:*   * *Resource utilization using SLS* * *Resource utilization = Number of RB per cell used by traffic during observation time / Total number of RB per cell available for traffic over observation time* * *Note: For DL RU, the total number of RB per cell available for traffic over observation time only counts the DL RBs without considering the guard band and UL RBs. Similarly, for UL RU, the total number of RB per cell available for traffic over observation time only counts the UL RBs.* * *DL/UL ~~received~~ SINR using SLS* |
| Ericsson | **Resource Utilization per direction**  ***Proposal 16:*** RAN1 to agree that companies report Resource Utilization (RU) as a fraction of the number of occupied resources used for a particular link direction to the total number of resources available for the link direction.  ***Proposal 18:*** RAN1 to agree that the traffic load in system level simulations is based on an aggregated system resource utilization between UL and DL based on the reference static TDD network 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 link direction. |
| Qualcomm | ***Proposal 11:*** For the definition the UPT CDF metric of {mean, 5%, 50% and 95%}, the UPT for each packet of the UE should be first computed then the 5%, 50% and 95% is computed for each UE. The CDF of {5%, 50% and 95%} is then collected based on all UEs.  ***Proposal 12:*** The resource utilization metric for DL (or UL) is computed based on the ratio of the scheduled DL (or UL) RBs to the total number of DL (or UL) RBs within the simulation time.  ***Proposal 13:*** For subband full duplex evaluation scenario, support SBFD slot utilization is additional metric.  Additional useful metric is the utilization of SBFD slot for both traffic direction. |
| DOCOMO | ***Proposal 5***: DL Geometry and Coupling gain are baseline for calibration metrics, and UL SINR is considered for additional calibration metrics for Deployment Case 1. |
| CATT | ***Proposal 3:*** Adopt the following definitions for SLS metrics for duplex enhancement evaluation.   * UPT: defined as the size of a packet divided by the time between the arrival of the packet and the reception of the last bit of the packet. * Latency: defined as the time between the arrival of the packet and the reception of the last bit of the packet. * Resource utilization: defined as the number of RBs per cell used by UL/DL traffic during observation time divided by total number of RB per cell available for UL/DL traffic over observation time; or, defined as the number of RB per cell used by UL/DL traffic during observation time divided by total number of RB per cell available for UL&DL traffic over observation time. * DL/UL received SINR: (BS/UE Tx power - coupling loss) / (noise + legacy inter-cell interference from N interference sources + CLI from M interference sources)   + FFS whether dominant interference sources or all the interference sources are taken into account   + Coupling loss includes all kinds of losses (e.g. path loss and penetration loss) minus gains (e.g. Tx antenna gain, Rx antenna gain). |
| Nokia, Nokia Shanghai Bell | ***Proposal 12:*** The resource utilization (RU) for a given link direction is calculated as the number of occupied resources for the link direction divided by the total amount of available resources irrespective of the link direction. |
| Spreadtrum, BUPT | ***Proposal 7:*** Resource utilization on downlink resources, uplink resources and all total resources should be given as an evaluation metric.  ***Proposal 8:*** Proportion of downlink/uplink UEs in one cell should be defined in SBFD SINR calibration. |
| Xiaomi | ***Proposal 6:*** The definition provided in Table 1 is adopted for SBFD and dynamic/flexible TDD evaluation.  ***Proposal 7:*** Either DL/UL UPT or user throughput (CDF or {mean, 5%, 50%, 95%}) is applicable to SBFD and dynamic/flexible TDD evaluation. User throughput is slightly preferred.  **Table 1: Summary of definition for output metrics**   |  |  |  | | --- | --- | --- | | Output metric | Definition | Source | | DL/UL UPT | UPT CDF   * File throughput is calculated per file * Unfinished files should be incorporated in the UPT calculation.   + The number of served bits (possibly zero) of an unfinished file by the end of the simulation is divided by the served time (simulation end time – file arrival time). | TR36.889 | | User throughput | User throughput = amount of data (file size) / time needed to download data   * Time needed to download data starts when the packet is received in the transmit buffer, and ends when the last bit of the packet is correctly delivered to the receiver | TR36.814 | | Latency | Latency = time needed to download data starts when the packet is received in the transmit buffer, and ends when the last bit of the packet is correctly delivered to the receiver |  | | Resource utilization | Resource utilization = Number of RB per cell used by traffic during observation time / Total number of RB per cell available for traffic over observation time | TR36.814 | | DL/UL received SINR | Received SINR = Effective signal power / (Interference+Noise) |  | | Coverage | The budget template defined for coverage enhancement can be used as a starting point. Self-interference and CLI should be reflected. | TR38.830 | |
| Vodafone, China Telecom, Telecom Italia | ***Proposal 1:*** *Introduce an evaluation metric for the additional energy consumption of SBFD at the BS side.*  ***Proposal 2:*** *Define the additional energy consumption for SBFD as follows:*   * *Percentage of the additional energy consumption for SBFD.* * *Total energy consumption from all DPDs used in SBFD (including energy consumption from all feedback chains).* * *Total energy consumption from all PAs used in SBFD.* * *Total energy consumption from SIC used in SBFD (including any additional associated components).* * *Total energy consumption from all DPDs used in legacy TDD that was compared with SBFD (including energy consumption from all feedback chains).* * *Total energy consumption from all PAs used in legacy TDD that was compared with SBFD.* |
| Dell | ***Proposal 6:*** Performance evaluation criteria are: average UL SINR, DL and UL radio latency, and average UL and DL user throughput. The latency metric is captured similarly to that is of the URLLC evaluations, implying the delay from the moment the packet is generated until it is being successfully received at the intended receiver, including the HARQ retransmission delay. |
| Samsung | ***Proposal 6:*** *For performance metrics, use the following definition*   * *DL/UL UPT CDF and (5%-tile, 50%-tile, 95%-tile): DL/UL UPT (in a unit of bps) of a UE is defined as total size of transmitted packets divided by total packet transmission time.* * *Latency CDF and (5%-tile, 50%-tile, 95%-tile): The latency (in a unit of sec) can be defined as a packet transmission time which includes scheduling time and re-transmission time with a given traffic model.* * *Resource utilization : The resource utilization (in a unit of percentage) is can be defined as the number DL/UL RB per cell used by traffic during observation time is divided total number DL/UL RB per cell available for traffic over observation time as in TR36.814.* * *DL/UL received SINR: Wideband SINR from independent UE drops (geometry SINR), as used in TR37.910* |

### Summary

Regarding UPT (user perceived throughput) related performance metrics for FTP model 3 in SLS, moderator suggests **Initial proposal 2-2-1** based on the submitted proposals.

Regarding latency related performance metric for FTP model 3 in SLS, moderator suggests **Initial proposal 2-2-2** based on the submitted proposals.

Regarding RU (Resource utilization) in SLS, moderator suggests **Initial proposal 2-2-3** based on the submitted proposals.

Regarding DL/UL SINR related metrics in SLS, moderator suggests **Initial proposal 2-2-4** based on the submitted proposals.

For calibration, the calculation of DL/UL SINR related metrics are based on the common understanding on the calculation of coupling loss, moderator suggests **Initial proposal 2-2-5 and 2-2-6** for the definition of coupling loss based on the submitted proposals.

For calibration, moderator suggests **Initial proposal 2-2-7** for the detailed calculation method of legacy DL SINR based on the submitted proposals.

Regarding the detailed calculation methods of SBFD DL SINR / legacy UL SINR/ SBFD UL SINR, they can be discussed later.

### 1st Round Proposals

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

For UPT (user perceived throughput) related performance metrics for FTP model 3 in SLS, adopt option 1 of the following definitions.

* Option 1: UPT is defined as the size of an FTP packet divided by the time which starts when the packet is received in the transmit buffer and ends when the last bit of the packet is correctly delivered to the receiver [Refer to TR36.814].
  + Unfinished FTP packets should be incorporated in the UPT calculation. The number of served bits (possibly zero) of an unfinished FTP packet by the end of the simulation is divided by the served time (simulation end time – file arrival time) [Refer to TR36.889].
  + Average-UPT of a user: defined as the average from all UPTs for all FTP packets intended for this user [Refer to TR36.814].
  + Tail-UPT of a user: defined as the worst 5% UPT among all FTP packets intended for this user [Refer to TR36.814].
  + Average-UPT CDF: The CDF of the average UPTs for all users.
  + Tail-UPT CDF: The CDF of the tail UPTs for all users.
  + Mean/5%/50%/95% Average-UPT: The mean/5%/50%/95% value of Average-UPTs for all users.
  + Mean/5%/50%/95% Tail-UPT: The mean/5%/50%/95% value of Tail-UPTs for all users.
* Option 2: UPT of a user is defined as the total size of the packets generated for the user divided by the time which starts when the first packet is received in the transmit buffer and ends when the last bit of the packet is correctly delivered to the receiver if all the packets are finished by the end of the simulation, otherwise ends at the simulation end time.
  + UPT CDF: The CDF of the UPTs for all users.
  + Mean/5%/50%/95% UPT: The mean/5%/50%/95% value of UPTs for all users.
* Option 3: UPT of a user is defined as the total size of the transmitted packets of the user divided by the total packet transmission time.
  + The transmission time of a packet is defined as the time which starts when the packet is received in the transmit buffer and ends when the last bit of the packet is correctly delivered to the receiver if the packet is finished by the end of the simulation, otherwise ends at the simulation end time.
  + UPT CDF: The CDF of the UPTs for all users.
  + Mean/5%/50%/95% UPT: The mean/5%/50%/95% value of UPTs for all users.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | Our preference is to adopt the same definition as use in the past and we are OK with option 1. |
| Spreadtrum | Prefer option 1 and we also suggest to discuss on how to consider the packet that is not correctly delivered. |
| Ericsson | Option 1. |
| New H3C | Option 1 |

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

For latency related performance metric for FTP model 3 in SLS, adopt option 1 of the following definitions.

* Packet latency: defined as the time which starts when the packet is received in the transmit buffer and ends when the last bit of the packet is correctly delivered to the receiver if the packet is finished by the end of the simulation, otherwise ends at the simulation end time.
  + Option 1: Calculate the latency for each packet for each UE, and then calculate the average latency for each UE, then generate the CDF for these average latency for each UE
    - UE-Average-Latency: defined as the average packet latency for a UE
    - UE-Average-Latency CDF: The CDF of the UE-Average-Latency for all users.
    - Mean/5%/50%/95% UE-Average-Latency: The mean/5%/50%/95% value of UE-Average-Latency for all users.
  + Option 2: Calculate the latency for each packet for each UE, and then generate CDF of latency for all these packets from all the UEs.
    - Packet-Latency CDF: The CDF of the packet latencies of all the packets from all the UEs.
    - Mean/5%/50%/95% Packet-Latency: The mean/5%/50%/95% value of Packet-Latency of all the packets from all the UEs.
* Note: HARQ re-transmission should be considered for latency evaluation.

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| Sony | Option 2 provides a better view of UE’s latency as the very poor and very good latencies in each UE is not averaged out like in Option 1. Hence, we prefer Option 2. |
| Intel | We have a slight preference for Option 2, since this may allow to capture the full spectrum of latencies occurring at each UE, while this may not be possible when averaging. Furthermore, for latency sensitive traffic, what matters is the per-packet latency more than a “per UE metric”. Thus, Option 2 is sufficient and requires less simulation time to obtain sufficient data points for packet latency statistics/CDF. |
| Spreadtrum | We prefer option 1. Since specific traffic model is set for one simulation, we think the average performance of a UE is also meaningful. |
| Ericsson | We support the proposal and prefer Option 2. |
| New H3C | We slightly prefer option 1 |

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

Two types of RU (Resource utilization) are defined for SBFD evaluation.

* Type-1 RU: DL/UL Type-1 RU = Number of RBs per cell used by traffic for the given link direction during observation time / Total number of all the RBs per cell including DL, UL and guard bands over observation time.
* Type-2 RU (Follow TR 36.814): DL/UL Type-2 RU = Number of RBs per cell used by traffic for the given link direction during observation time / Total number of RBs per cell available for traffic for the given link direction over observation time
* Note: In case of MU-MIMO, one RB allocated to N users within a cell is only counted as used once.

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| Sony | Type 1 RU allows the resource utilisation at least for the DL to be compared with legacy (non-SBFD) case.  If we use a constant subband size, then Type 2 RU is not needed as the DL or UL resource utilisation over the total DL resource or total UL resource can be derived. If the subband is dynamic then we may need Type 2 RU to see if there is a bottleneck due to subband size configuration (i.e. the size of the subband is limiting the DL/UL throughput).  We think both measurements are useful, so we think we can report Type 1 and Type 2 RU. |
| Intel | The type-1 RU definition is slightly preferred, and more proper when comparing SBFD case with the legacy static TDD. |
| Spreadtrum | We suggest to take those two types of RU into account. As we can see the RU for all resource in type1 and get the performance for UL/DL separately in type2. |
| Ericsson | We support the proposal and are ok with both types. |
| New H3C | We are fine with the proposal |

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

For DL/UL SINR related metrics in SLS, the following metrics are considered.

* Coupling loss: CDF of coupling loss from Tx antenna port 0 of gNB (serving cell) to Rx antenna port 0 of UE
* Legacy DL SINR: CDF of legacy DL wideband pre-processing SINR considering legacy gNB-UE interference only
* SBFD DL SINR: CDF of SBFD DL pre-processing SINR considering legacy gNB-UE interference and UE-UE co-channel inter-subband CLI
* Legacy UL SINR: CDF of legacy UL pre-processing SINR considering legacy UE-gNB interference only
* SBFD UL SINR: CDF of SBFD UL pre-processing SINR considering legacy UE-gNB interference, self-interference, inter-site gNB-gNB co-channel inter-subband CLI and co-site inter-sector co-channel inter-subband CLI

Companies are encouraged to provide comments in the table below.

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| --- | --- |
| **Company** | **Comment** |
| Sony | Is the Legacy UL/DL SNIR for non SBFD slots or for the case where SBFD is not configured? Otherwise it isn’t clear why we need to exclude interference caused by CLI in calculating SNIR, i.e. legacy UL/DL SNIR will always be higher than SBFD SNIR if we remove the interferences from the calculation. |
| Spreadtrum | We want to clarify is the pre-processing SINR here is a geometry SINR? |
| Ericsson | Same question as Spreadtrum. Not clear to us what pre-processing SINR is. |
| New H3C | Definition of the pre-processing SINR isn’t clear to us. |

#### ***Initial proposal 2-2-5:***

Consider following for the definition of coupling loss ( from Tx antenna port *p* of transmitter *A* to Rx antenna port *u* of receiver *B:*

**If both large scale fading and small scale fading are modelled, the coupling loss from Tx antenna port p of transmitter A to Rx antenna port u of receiver B is defined in formula (1) which is based on formula (B.1-2) in TR 37.910 with differences highlighted in *red.***

Where

* *N* is the number of clusters, *M* is the number of rays per cluster.
* The complex weight vector () is used for virtualization of Tx antenna port *p* of transmitter , and () is used for virtualization of Rx antenna port *u* of receiver .

For NLOS case for *n*=1, …, *N*, and *m*=1, …, *M*.

with the notations , , , , , , , , , being according to equation (7.5-22) and (7.5-28) in TR38.901, and is the Ricean K-factor;

and for LOS case

with the notations , , , , and being according to equation (7.5-29) in TR38.901;

and and are the field patterns of multiple weighted Tx antenna ports {*p*| *p* =1,2,…,*S* } in the direction of the spherical basis vectors, and respectively, and are the field patterns of Rx antenna port *u* in the direction of the spherical basis vectors, and respectively; they are given by

wherein,

* within and , for LOS case, and for NLOS case.
* within and , for LOS case, and for NLOS case.

where *N*T is the number of antenna elements that virtualizes the Tx antenna port *p*, *N*R is the number of antenna elements that virtualizes the Rx antenna port *u*; (*k*=1, …, *N*T) represents a complex weight vector used for virtualization of Tx antenna port *p*, (*l*=1, …, *N*R) represents a complex weight vector used for virtualization of Rx antenna port *u*, *Ftx,k,θ* and *Ftx,k,ϕ* are the *k*th transmit antenna element’s field patterns according to equation (7.1-11) in TR38.901 in the direction of the spherical basis vectors,  and  respectively, *Frx,l,θ* and *Frx,l,ϕ* are the *l*th receive antenna element’s field patterns according to equation (7.1-11) in TR38.901in the direction of the spherical basis vectors,  and  respectively.

**If only large scale fading is modelled, the coupling loss from Tx antenna port *p* of transmitter *A* to Rx antenna port *u* of receiver *B* is defined in formula (2).**

where the calculation of , , , is same as in formula (1).

The coupling loss (CL) from Tx antenna port 0 of gNB to Rx antenna port 0 of UE is expressed as

where,

* The complex weight vector (used for virtualization of one Tx antenna port at gNB ) and (used for virtualization of one Rx antenna port at UE ) are selected by selecting the best beam pair of gNB and UE , based on the criteria of maximizing receive power after beamforming.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### ***Initial proposal 2-2-6:***

Regarding coupling loss from Tx antenna port 0 of gNB to Rx antenna port 0 of UE , it can be expressed as

where,

* The complex weight vector (used for virtualization of one Tx antenna port at gNB ) and (used for virtualization of one Rx antenna port at UE ) are selected by selecting the best beam pair of gNB and UE , based on the criteria of maximizing receive power after beamforming.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### ***Initial proposal 2-2-7:***

Regarding the legacy DL wideband pre-processing SINR of UE *B* in severing cell *A*, it can be expressed as

where,

wherein,

* is the total DL transmit power (over the *S* Tx antenna ports) per subcarrier.
* is the antenna port number of gNB and is the Rx antenna port number of UE.
* The complex weight vector (used for virtualization of one Tx antenna port at gNB ) and (used for virtualization of one Rx antenna port at UE ) are selected by selecting the best beam pair of gNB and UE , based on the criteria of maximizing receive power after beamforming.
* The complex weight vector (used for virtualization of one Tx antenna port at gNB ) is randomly selected.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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## Issue#2-3: Layout and UE distribution

### Submitted proposal

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| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1****: For SBFD deployment case 1, evaluation assumptions in Table 15 and Table 16 in Annex B can be considered as starting point.*  **Deployment Case 1**  ***Proposal 2****: For UE distribution of Urban Macro scenario for FR1 and Dense Urban Macro layer scenario for FR1 and FR2-1 in SBFD Deployment Case 1,*   * *Baseline: 10 users per macro TRP, and all users are randomly and uniformly dropped within the macro TRP.* * *Optional (UE clustering):*    + *Step 1: Randomly drop [3] UE cluster center within one macro cell geographical area considering the minimum distance between macro TRP to UE cluster center as Dmacro-to-cluster and the minimum distance between to UE cluster centers as Dinter-cluster*   + *Step 2: 2/3 users randomly and uniformly dropped within the UE clusters with the radius of R, 1/3 users randomly and uniformly dropped throughout the macro geographical area, and 10 users per macro geographical area.*   + *For Urban Macro for FR1: Dmacro-to-cluster = [262.5 m], Dinter-cluster = [114.8 m], R = [72.3 m]*   + *For Dense Urban Macro layer for FR1 and FR2-1: Dmacro-to-cluster = [105 m], Dinter-cluster = [57.9 m], R = [28.9 m]*   ***Proposal 3****:* *For UE outdoor/indoor proportion in Dense Urban Macro layer scenario and Dense Urban Micro layer scenario for FR2-1 in SBFD Deployment Case 1:*   * *Baseline: 20% Outdoor in cars: 30km/h, 80% Indoor in houses: 3km/h* * *Optional: 100% Outdoor in cars: 30km/h*   ***Proposal 4****: For Dense Urban with 2-layer for FR1 and Dense Urban Micro layer for FR2-1 in SBFD Deployment Case 1, consider micro cell TRP deployment as following*   * *One-sector deployment* * *Step 1: Randomly drop [3] micro TRP centers within one macro cell geographical area considering the minimum distance between micro TRP centers (Dinter-micro-center) and the minimum distance between macro TRP to micro TRP center (Dmacro-to-micro-center).* * *Step 2: Randomly deploy one micro TRP on the area circle around each micro TRP center with the radius of half of Dinter-micro-center* * *Step 3: Determine the horizontal angle of the micro TRPs with the planer facing to the micro TRP center.* * *Dinter-micro-center =[57.9 m], Dmacro-to-micro-center = [105 m]*     Figure 1 Cell layout for dense urban with 2-layer for FR1.  ***Proposal 5****: For Dense Urban with 2-layer for FR1 in SBFD Deployment Case 1, consider UE distribution as following*   * *For FTP traffic model 3: 2/3 users randomly and uniformly dropped around micro TRP centers with the radius of R (R = [28.9m]), 1/3 users randomly and uniformly dropped throughout the macro geographical area, and 60 users per macro geographical area.*   ***Proposal 6****: For Dense Urban Micro layer for FR2-1 in SBFD Deployment Case 1,*   * *Regarding layout, only consider the Micro layer within a 2-layer Dense Urban network. All users communicate with micro cell, i.e. macro cell is only used for determining position of micro cell. As a layout of macro cell and micro cell, adopt the same layout as Dense Urban with 2-layer for FR1.* * *Regarding UE distribution, 10 users per Micro TRP, and all users are randomly and uniformly dropped around Micro TRP center with the radius of R (R = [28.9m]).*   **Deployment Case 4**  ***Proposal 7****: For SBFD Deployment Case 4,*   * *For each operator, reuse the evaluation assumptions for Urban Macro (FR1) and Dense Urban Macro layer (FR2-1) of SBFD Deployment Case 1 as much as possible.* * *For the 0% and 100% grid shift between two networks,* *the layout shown in Figure 2 can be considered for RAN1 evaluation.*     Figure 2 0% and 100% grid shift between two networks for Urban Macro and for Dense Urban Macro layer.  **Deployment Case 3**  ***Proposal 8****: For SBFD Deployment Case 3-2,*   * *For Dense Urban with 2-layer for FR1, reuse the evaluation assumptions of Dense Urban* *with 2-layer scenario in SBFD Deployment Case 1 as much as possible.* * *For HetNet with Urban Macro and Indoor office, reuse the evaluation assumptions of Urban Macro scenario and Indoor office scenario in SBFD Deployment Case 1 as much as possible with the following assumption*   + *Macro layer: Hexagonal grid, 19 micro sites, 3 sectors per site, ISD=500m*   + *Indoor layer:*      - *One building randomly dropped per macro cell*     - *The minimum distance between Macro to Indoor TRxP: [35] m*     - *Layout for each building: Indoor with single floor ([3] BSs per 120m x 50m)*   + *UE distribution:*      - *2/3 users randomly and uniformly dropped within the building, 1/3 users randomly and uniformly dropped throughout the macro geographical area, and [60] users per macro geographical area.*     Figure 3 HetNet with Urban Macro and Indoor office.  ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.* |
| Huawei | ***Proposal 1:*** *For SBFD Deployment Case 1 to 4, a cell layout of hexagonal grid with 7 macro sites and 3 sectors per site with wrap around is adopted for Urban Macro and Dense Urban Macro layer.*  **Deployment Case 1**  ***Proposal 2:*** *For SBFD Deployment Case 1, the UE distribution for Urban Macro and Dense Urban Macro layer is given as follows:*   * *Option 1:*   + *10 users per macro TRP for FTP traffic model 3;*   + *20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h.* * *Option 2 (for Urban Macro):*   + *Step 1: Randomly drop a cluster within a macro cell geographical area considering the minimum distance between macro TRP to cluster center, e.g., 100m, where the size of each cluster is (m);*   + *Step 2: 80% UEs are randomly and uniformly dropped within the clusters, and 20% UEs are randomly and uniformly dropped outside the clusters and throughout the macro geographical area;*   + *Note: 10 users per macro TRP for FTP traffic model 3 and all the UEs are indoor with 3km/h.*     Fig. 1 UE clustering for Urban Macro.  ***Proposal 5:*** *For SBFD Deployment Case 3, adopt the following 2-step method for the HetNet scenario:*   * *Step 1: Drop an Urban Macro layer with hexagonal grid with 7 macro sites and 3 sectors per site;* * *Step 2: Randomly drop an indoor factory/office layer with 12 BSs per (m) throughout the macro geographical area considering the minimum distance between macro TRP to indoor office center, e.g., 100m.*   ***Proposal 6:*** *For SBFD Deployment Case 3, adopt the following UE distribution for the HetNet scenario:*   * *Urban Macro layer:*   + *10 users per macro TRP for FTP traffic model 3;*   + *20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h;* * *Indoor office layer:*   + *6 users per Pico TRP for FTP traffic model model 3;*   + *100% indoor in houses: 3km/h.*     Fig. 3 Cell layout for HetNet scenario.  **Deployment Case 4**  ***Proposal 7:*** *For SBFD Deployment Case 4, adopt the same UE clustering for SBFD Deployment Case 1 and consider different grid shift between two operators, e.g., 0% and 100%.*  ***Proposal 8:*** *Adopt the evaluation assumptions of deployment scenarios for SBFD Deployment Case 1-4 in Table A.1.*    (a) 0% (b) 100%  Fig. 4 Grid shift for Deployment Case 4. |
| ZTE | ***Proposal 8****: RAN1 considers 0% and 100% grid shift for Case 4 with different operators for SBFD simulation.*   * *FFS the topology for different percentage of grid shift.*   ***Proposal 9****: RAN1 considers UE cluster model in the SBFD simulation. FFS details, e.g.,*   * *What’s the area of this UE cluster;* * *How many UE clusters are there in each cell;* * *How many UEs are dropped within each cluster;* |
| Ericsson | ***Proposal 13***: Regarding evaluation scenarios, two-operator urban macro scenario should be prioritized and 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 evaluation of coexistence scenarios in RAN1, consider grid shifts of 0% and 100%.  ***Proposal 15***: RAN1 to agree to implement UE clustering in system level simulations with at least one cluster per cell and all the users inside the cluster are indoors  This can occur when there are groups of indoor UEs clustered in buildings, similar to layout 2 in Table 5.2.1.1.2-1 in 38.828 [4]. |
| Samsung | ***Proposal 4***: *RAN1 adopts the following UE side assumptions:*   * *UE outdoor/indoor proportion:*   + *80% indoor UEs and 20% outdoor UEs as in TR38.901*   + *Further discuss whether other UE proportion such as less than 80% indoor UEs is needed or not* * *UE distribution*   + *Uniform UE distribution, as in TR38.901* * *Minimum UE-to-UE distance*   + *3m for macro/micro cell and 1~3m for indoor*   + *Further discuss whether 1m for macro/micro cell is needed or not*   ***Proposal 5***: *For Deployment case, the following grid shift is considered as mandatory*   * *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)* * *For Indoor hotspot deployment (if agreed)*   + *Two operators’ gNBs are located at the same (0% grid shift)*   + *FFS: other grid shift values*   ***Proposal 8***: For evaluation purpose, RAN1 takes the deployment related parameters in Tables 2-4 as a starting point. |
| Qualcomm | ***Proposal 3:*** Grid shift of 0% and 100% between the two operators’ gNB are sufficient to study best case and worst-case adjacent channel coexistence between the SBFD and static TDD operator (Deployment case 4).   * FFS: 50% grid shift   ***Observation 5:*** A simple model of UE clustering is essential for useful evaluation of impact of inter-UE CLI.  ***Proposal 4:*** UE clustering by dropping one cluster within each macro cell area and drop 2/3 of the UE within the cluster and the rest 1/3 uniformly dropped to entire macro area.   * FFS: cluster size * FFS: minimum distance between cluster centre and gNB   ***Proposal 5***: No minimum distance between the UEs is considered for the Rel-18 study on duplex evolution.  ***Proposal 6***: For InH, support ceiling mounted TRP deployment with Boresight direction is perpendicular to the ceiling and layout parameters in Table 1.  ***Proposal 7:*** For UMa, support hexagonal grid cell layout with 7 macro sites, 3 sector per side (ISD = 500) related configuration in Table 2.  ***Proposal 8:*** Support 100% outdoor UE locations to evaluate outdoor scenarios for FR2.  ***Proposal 9:*** For HetNet, support UMa hexagonal grid of 7 macro sites and 3 sectors per site (ISD = 500m).   * one InH layout is dropped randomly for each macro sector. * The Indoor office is assumed single floor of size 120m x 50m x 3m with 3-site deployment. |
| vivo | ***Proposal 3****: For SBFD Deployment Case 4, at least consider the following scenarios for evaluation from RAN1 perspective:*   * *80% indoor UEs and 20% outdoor UEs in Urban Macro and Dense Urban Macro layer* * *The grid shift is 100% between two operators* * *Indoor Hotspot can also be considered for FR1 and FR2.* |
| CATT | ***Proposal 7:*** Uniform UE distribution for urban macro and dense urban scenarios is the baseline and FFS details of UE clustering.  ***Proposal 8:*** Adopt 0% grid shift and 100% grid shift for deployment Case 4 for SBFD. |
| Nokia, Nokia Shanghai Bell | ***Observation 2:*** For the placement of UEs in UMa scenario, the default assumption of uniform distribution of UEs (in x-y plane) results in large physical separation between UEs meaning that the effects of UE-UE inter-subband interference may not be as high as compared to real life. Simulation results show no impact on the UE DL throughput performance when comparing the cases with and without UE-UE interference modelling.  ***Observation 3:*** Based on our UE-to-UE interference analysis in R4-2212848, performance degradation due to UE-to-UE interference starts to occur when the corresponding coupling loss is 80 dB or less.  ***Proposal 8:*** To better model the effects of UE clustering in the UMa scenario, consider an alternative UE placement method where a certain proportion of the users are inside the same building, e.g. an indoor office building with multiple UEs is placed in each cell area (similar as for the scenarios discussed under dynamic/flexible TDD), or one or more ‘UE hotspots’ are placed in each area similar as the ones defined in LTE small cell study TR 36.932. |
| MediaTek | ***Observation 1:*** Uniform random distribution does not depict a real-world scenario whereby users congregate to form groups/clusters.  ***Observation 2:*** The uniform random distribution results in separation distance between the UEs that is relatively large. Consequently, the effect of inter-UE CLI will not be captured in the evaluations.  ***Proposal 3:*** For the evaluations of SBFD and DTDD schemes, RAN1 should consider clustered UEs deployments to accurately capture the impact of inter-UE CLI.  ***Proposal 4:*** 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. |
| Spreadtrum, BUPT | ***Proposal 4:*** UE outdoor/indoor proportion in TR 38.901 should be adopted as baseline in urban macro scenarios and realistic UE outdoor/indoor proportion considering UE clustering could be an optional scenario and reported by companies.  ***Proposal 5:*** Evaluation assumptions on the deployment of indoor office and proportion of indoor/outdoor UE in Hetnet scenario should be further studied. |
| Xiaomi | ***Proposal 1:*** For deployment case 1, indoor office/urban macro/dense urban defined in TR38.802/TR38.901 should be reused:   * 80% indoor UE and 20% outdoor UE is assumed * Deprioritize Rural scenario * FR2-2 is not considered for SBFD evaluation. |
| Intel | ***Proposal 3:*** For deployments case 1-2 and 3 with single-layer for SBFD for both FR1 and FR2-1:   * Uniform dropping with 100% indoor UEs could be considered for indoor office scenario. * Clustered dropping and uniform dropping could be instead considered at the same priority level for all other deployments with [80:20]% indoor: outdoor ratio. |
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### Summary

There was a discussion in RAN1#109-e on scenarios, with agreements as following.

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| Agreement  For SBFD Deployment Case 1, at least consider the following scenarios for evaluation:   * For FR1,   + Indoor office (use Indoor office defined in TR38.802/TR38.901 as starting point)   + Urban macro (use Urban macro defined in TR38.802/TR38.901 as starting point)     - FFS: UE outdoor/indoor proportion, clustering, etc   + Optional: Dense Urban with 1-layer or 2-layer (use Dense Urban defined in TR38.802/TR38.901 as starting point)   + FFS: Rural * For FR2-1,   + Indoor office (use Indoor office defined in TR38.802/TR38.901 as starting point)   + Dense Urban Macro layer (use Dense Urban defined in TR38.802 as starting point)     - FFS: UE outdoor/indoor proportion, clustering, etc   + Optional: Dense Urban micro (use Dense Urban micro defined in TR38.802/TR38.901 as starting point) * FFS: Whether FR2-2 is considered or not in Rel-18.   Note: For optional scenarios, they can be captured in TR and it is up to each company to provide the results. The results can be used to draw conclusion/recommendation depending on the number of companies providing the results.  Agreement  For SBFD Deployment Case 4, at least consider the following scenarios for evaluation from RAN1 perspective:   * FR1: Urban Macro * FR2-1: Dense Urban Macro layer * FFS: UE outdoor/indoor proportion, clustering, etc * FFS: the grid shift between two networks, e.g., 0%, 100%   FFS: Indoor hotspot, Dense Urban Micro layer |

**UE clustering**

Uniform UE distribution for Urban Macro and Dense Urban Macro layer scenarios can be considered as the baseline [Huawei, CATT, Samsung, CMCC], and UE clustering as well as the corresponding UE outdoor/indoor proportion needs to be considered as an alternative to accurately capture the impact of inter-UE CLI [Huawei, Ericsson, ZTE, Qualcomm, Nokia, MediaTek, Spreadtrum, Intel, CMCC].

Regarding UE clustering, two options are proposed:

* Opt 1: UE clustered in one or more buildings with the building topology explicitly modelled [Huawei, Ericsson, Nokia]
* Opt 2: UE clustered in one or more hotspots, and each hotspot is modelled with a randomly dropped cluster center and a radius R [Qualcomm, Nokia, CMCC]

For each option, the following details should to be determined [ZTE]:

* What’s the area of this UE cluster
* How many UE clusters are there per macro cell geographical area
* How many UEs are dropped within each cluster

The UE clustering methods proposed by Huawei and CMCC can be a starting point for discussion.

* Method based on Option 1 [Huawei]:
  + Step 1: Randomly drop one cluster within a macro cell geographical area considering the minimum distance between macro TRP to cluster center, e.g., 100m, where the size of each cluster is 120×50 (m);
  + Step 2: 80% UEs are randomly and uniformly dropped within the clusters, and 20% UEs are randomly and uniformly dropped outside the clusters and throughout the macro geographical area;
  + Note: All UEs within the UE cluster are indoor with 3km/h
* Option 2 based on Option 2 [CMCC]:
  + Step 1: Randomly drop [3] UE cluster center within one macro cell geographical area considering the minimum distance between macro TRP to UE cluster center as Dmacro-to-cluster and the minimum distance between to UE cluster centers as Dinter-cluster
  + Step 2: 2/3 users randomly and uniformly dropped within the UE clusters with the radius of R, 1/3 users randomly and uniformly dropped throughout the macro geographical area, and 10 users per macro geographical area.
  + For Urban Macro for FR1: Dmacro-to-cluster = [262.5 m], Dinter-cluster = [114.8 m], R = [72.3 m]
  + For Dense Urban Macro layer for FR1 and FR2-1: Dmacro-to-cluster = [105 m], Dinter-cluster = [57.9 m], R = [28.9 m]
  + Note: there are both outdoor and indoor UEs in the UE cluster.

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

**Micro TRP dropping method in Dense Urban**

In TR 38.802, two options of one sector deployment for micro cell TRP are considered as following.

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| [TR 38.802, Clause A.2.1]  For Dense urban, the following Option 1 and Option 2 are adopted with one sector deployment for micro cell TRP deployment in dense urban scenario, i.e.,  - Option 1 : Omni in horizontal, directional in vertical (5dBi gain, HPBW 40°, vertical tilt 90°, Am =20dB, SLAV=30dB)  - Dropping in the center of the hotspot area  - Option 2: Directional in horizontal, directional in vertical (8dBi gain, HPBW = 65°, vertical tilt 90°, Am =30dB, SLAV=30dB)  - One-sector deployment  - Dropping of TRP and TRP antenna orientation according to the following three steps as described in TR 36.897 (non co-channel hetnet deployment)  Step 1: Randomly drop TRP centers around the TRP cluster center within a radius of R; and consider the minimum distance between TRP centers (Dmicro-TRP).  Step 2: Randomly deploy TRP antennas on area circle with the radius of half of Dmicro-TRP.  Step 3: Determine the horizontal angle of the TRPs with the planer facing to the TRP center.  - Number of Tx antennas at micro cell TRP:  - Baseline: (M, N, P, Mg, Ng) = (8, 8, 2, 1, 1), (0.5, 0.8)λ for 4GHz |

CMCC observes that

* For Option 1, the micro cell TRP with omni horizontal antenna radiation pattern is dropped in the center of the hotspot area. However, it is hard to understand how to realize omni horizontal antenna radiation pattern with antenna configuration (M, N, P, Mg, Ng) = (8, 8, 2, 1, 1). Thus, it is more realistic to consider directional horizontal antenna radiation pattern with the horizontal beamforming always points to the center of the hotspot area as in Option 2.
* Nevertheless, the description of Option 2 is not so clear especially regarding to how to drop TRP cluster center. To make it clear, the following TRP dropping method can be considered in Dense Urban with 2-layer scenario and Dense Urban Micro layer scenario.
  + One-sector deployment
  + Step 1: Randomly drop [3] micro TRP centers within one macro cell geographical area considering the minimum distance between micro TRP centers (Dinter-micro-center) and the minimum distance between macro TRP to micro TRP center (Dmacro-to-micro-center).
  + Step 2: Randomly deploy one micro TRP on the area circle around each micro TRP center with the radius of half of Dinter-micro-center
  + Step 3: Determine the horizontal angle of the micro TRPs with the planer facing to the micro TRP center.
  + Dinter-micro-center =[57.9 m], Dmacro-to-micro-center = [105 m]



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

**Dense Urban Micro layer for FR2-1**

CMCC observes that Dense Urban Micro layer is not defined in TR 38.802. Dense Urban with Micro layer defined in TR 38.828 for FR2-1 can be considered as starting point for SBFD evaluation, i.e.,

* Regarding layout, only consider the Micro layer within a 2-layer Dense Urban network. All users communicate with micro cell, i.e. macro cell is only used for determining position of micro cell. As a layout of macro cell and micro cell, adopt the same layout as Dense Urban with 2-layer for FR1.
* Regarding UE distribution, 10 users per Micro TRP, and all users are randomly and uniformly dropped around Micro TRP center with the radius of R (R = [28.9m]).

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

**Grid shift between two networks, e.g., 0%, 100%, for SBFD Deployment Case 4**

Most companies [Qualcomm, Huawei, ZTE, Ericsson, Samsung, CATT, MediaTek, CMCC] propose 0% and 100% grid shift between two networks can be considered as starting point, since 0% and 100% grid shift between two networks are sufficient to study best case and worst-case adjacent channel coexistence between the SBFD and static TDD operator.

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

**HetNet with Urban Macro and Indoor office**

For HetNet with Urban Macro and Indoor office, the following topology is suggested by companies:

* Macro layer: Hexagonal grid, 7 micro sites, 3 sectors per site, ISD=500m
* Indoor layer: One building randomly dropped per macro cell
  + Minimum distance
    - Option 1: The minimum distance between Macro to Indoor TRxP: [35 m] [CMCC]
    - Option 2: The minimum distance between Macro to indoor office center: [100 m] [Huawei]
  + Layout for each building:
    - Indoor with single floor ([3] BSs per 120m x 50m) [Qualcomm, CMCC]
    - Indoor with single floor ([12] BSs per 120m x 50m) [Huawei]
* UE distribution:
  + Option 1 [CMCC]
    - 2/3 users randomly and uniformly dropped within the building, 1/3 users randomly and uniformly dropped throughout the macro geographical area, and [60] users per macro geographical area
  + Option 2 [Huawei]
    - Urban Macro layer
      * 10 users per macro TRP for FTP traffic model 3
      * 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
    - Indoor office layer:
      * 6 users per Pico TRP for FTP traffic model model 3
      * 100% indoor in houses: 3km/h

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| CMCC | Huawei | Qualcomm |
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Moderator suggests **Initial proposal 2-3-5.**

**Others**

Two companies [Qualcomm, CMCC] consider 100% outdoor UE locations as an alternative to evaluate outdoor scenarios for FR2.

Huawei suggests for SBFD Deployment Case 1 to 4, a cell layout of hexagonal grid with 7 macro sites and 3 sectors per site with wrap around is adopted for Urban Macro and Dense Urban Macro layer.

Two campanies [Samsung, CATT] consider the minimum UE-to-UE distance as 3m for macro/micro cell and 1~3m for indoor.

Moderator suggests **Initial proposal 2-3-6, 2-3-7 and 2-3-8.**

### 1st Round Proposals

#### ***Initial proposal 2-3-1:***

For UE distribution of Urban Macro and Dense Urban Macro layer,

* Baseline:
  + 10 users per macro TRP, and all users are randomly and uniformly dropped within the macro cell
  + 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
* Optional (UE clustering): adopt option 2 of the following
  + 10 users per macro TRP
  + Option 1:
    - Step 1: Randomly drop *X* UE cluster centers within one macro cell geographical area considering the minimum distance between macro TRP to UE cluster center as Dmacro-to-cluster, where the size of each cluster is *L*×*W*
    - Step 2: *Y%* UEs are randomly and uniformly dropped within the UE clusters, and (1-*Y%*) UEs are randomly and uniformly dropped outside the clusters and throughout the macro geographical area
    - Note: UEs dropped within the UE cluster are indoor with 3km/h; UEs dropped outside the UE cluster are outdoor in car with 30km/h
    - FFS the values of X*, L, W,* Dmacro-to-cluster,*Y%*
      * E.g., for Urban Macro for FR1: *X* = 1, *L* = [120m], *W* = [50m], Dmacro-to-cluster = [100 m], *Y%* = [80%]
      * FFS for Dense Urban Macro layer
  + Option 2:
    - Step 1: Randomly drop *X* UE cluster centers within one macro cell geographical area considering the minimum distance between macro TRP to UE cluster center as Dmacro-to-cluster and the minimum distance between two UE cluster centers as Dinter-cluster
    - Step 2: *Y%* UEs are randomly and uniformly dropped within the UE clusters with the radius of R, (1-*Y%*) users randomly and uniformly dropped throughout the macro geographical area
    - Note: Each UE is assigned as indoor or outdoor based on the UE outdoor/indoor proportion, regardless whether the UE is dropped within the UE cluster or not.
    - UE outdoor/indoor proportion: 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
    - FFS the values of X*,* Dmacro-to-cluster, Dinter-cluster*,* R*, Y%*
      * *X*=[3], *Y%*=[2/3]
      * For Urban Macro for FR1: Dmacro-to-cluster = [262.5 m], Dinter-cluster = [114.8 m], R = [72.3 m]
      * For Dense Urban Macro layer for FR1 and FR2-1: Dmacro-to-cluster = [105 m], Dinter-cluster = [57.9 m], R = [28.9 m]

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Intel | We are OK with the proposal, but we feel that one between option 1 and 2 could be downselected, and there is no need to support both even if these are optional. |
| Spreadtrum | Agree with Intel. |
| Ericsson | We support Option 1. |
| New H3C | We are fine with the proposal |

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

For Dense Urban with 2-layer for FR1 and Dense Urban Micro layer for FR2-1, consider micro cell TRPs are deployed as following

* One-sector deployment
* Step 1: Randomly drop [3] micro TRP centers within one macro cell geographical area considering the minimum distance between micro TRP centers (Dinter-micro-center) and the minimum distance between macro TRP and micro TRP center (Dmacro-to-micro-center).
* Step 2: Randomly deploy one micro TRP on the area circle around each micro TRP center with the radius of half of Dinter-micro-center
* Step 3: Determine the horizontal angle of the micro TRPs with the planer facing to the micro TRP center.
* Dinter-micro-center =[57.9 m], Dmacro-to-micro-center = [105 m]



Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Ericsson | We support the proposal in principle. |
| New H3C | We are fine with the proposal |
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#### ***Initial proposal 2-3-3:***

For Dense Urban Micro layer for FR2-1,

* Regarding the layout, only consider the Micro TRPs of Dense Urban 2-layer network. All users communicate with micro TRPs, i.e. macro cell is only used for determining position of micro TRP.
* Regarding UE distribution, 10 users per Micro TRP, and all users are randomly and uniformly dropped around Micro TRP center with the radius of R (R = [28.9m]).

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### ***Initial proposal 2-3-4:***

For evaluation of adjacent-channel coexistence between two networks for Urban Macro and Dense Urban Macro layer scenarios in RAN1, consider grid shifts between two networks of 0% and 100%.

* the topologies shown below can be used for the 0% and 100% grid shift for RAN1 evaluation.



Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Ericsson | We support the proposal. |
| New H3C | We are fine with the proposal |
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#### ***Initial proposal 2-3-5:***

For HetNet with Urban Macro and Indoor office, consider the following topology

* Macro layer: Hexagonal grid, 7 micro sites, 3 sectors per site, ISD=500m
* Indoor layer:
  + One building randomly dropped per macro cell
  + Layout for each building: Indoor with single floor ([3] BSs per 120m x 50m)
  + The minimum distance between Macro to indoor office center: [100 m]
* UE distribution: Y% UEs are randomly and uniformly dropped within the building, and (1-Y%) UEs are randomly and uniformly dropped outside the building and throughout the macro geographical area, and N users per macro geographical area.
  + Note: UEs dropped within the building are indoor with 3km/h; UEs dropped outside the building are outdoor in car with 30km/h
  + Y%=[80%], N=[30]

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Spreadtrum | We want to clarify the position of indoor layer, is it played horizon or randomly? |
| Ericsson | We need some clarifications. Do HetNets scenario deploy CoMP ? what are the cell-range extension settings ? Do users associate only with one layer?  Furthermore, if the intention of the study is to compare Static TDD and SBFD/Dynamic TDD, the mobility setting does not matter. |
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#### ***Initial proposal 2-3-6:***

For UE outdoor/indoor proportion in Dense Urban Macro layer scenario and Dense Urban Micro layer scenario for FR2-1, consider the following:

* Baseline: 20% Outdoor in cars: 30km/h, 80% Indoor in houses: 3km/h
* Optional: 100% Outdoor in cars: 30km/h

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Ericsson | Need further clarification. Are indoor users all on the same floor? |
|  |  |
|  |  |

#### ***Initial proposal 2-3-7:***

For SBFD Deployment Case 1 to 4, a cell layout of hexagonal grid with 7 macro sites and 3 sectors per site with wrap around is considered for Urban Macro and Dense Urban Macro layer.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | For this option classical 19 hexagonal cell (i.e., 2-tier instead of 1-tier) with wrap around could be also considered. |
| Spreadtrum | We are open with this proposal. 7 hexagonal macro cells and 3 sectors per site or 19 hexagonal cell and 3 sectors per site are OK for us. |
| Ericsson | We support the proposal |
| New H3C | We are fine with the proposal |

#### ***Initial proposal 2-3-8:***

For NR duplex evolution evaluation, consider the minimum UE-to-UE distance as 3m for macro/micro cell and 1~3m for indoor.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | We are generally OK with the proposal. However, it may be more practical to set the UE-to-UE distance to a fixed value (i.e, 3m) regardless of the deployment. |
| Spreadtrum | Agree with Intel. |
| Ericsson | We are ok with the proposal. |
| New H3C | We are fine with the proposal |

## Issue#2-4: SBFD subband and slot configurations

### Submitted proposal

#### For SBFD

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1****: For SBFD deployment case 1, evaluation assumptions in Table 15 and Table 16 in Annex B can be considered as starting point.*  ***Proposal 17****:* *For performance evaluation and comparison between baseline legacy TDD operation and SBFD operation under SBFD Deployment Case 1, the SBFD UL subband is adjusted to about 26% of the channel bandwidth in Alt3.*   * *Alt 3 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):*    + *Legacy TDD: Static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U]*   + *SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [26%] of the channel bandwidth.*   ***Proposal 18****:* *Consider the following SBFD subband configurations as starding point for the four alternatives for performance evaluation and comparison between baseline legacy TDD operation and SBFD operation under SBFD Deployment Case 1.*   * *Alt 1/2/4:*    + *For FR1 with 100MHz channel bandwidth and 30kHz SCS (273 PRB)*     - *SBFD Subband configuration#1: DUD with <ND, NU, NG> = <103, 55, 6>*     - *SBFD Subband configuration#2: DU with < ND, NU, NG > = <212, 55, 6>*   + *For FR2-1 with 200MHz channel bandwidth and 60kHz SCS (264 PRB)*     - *SBFD Subband configuration#1: DUD with < ND, NU, NG > = <102, 54, 3>*     - *SBFD Subband configuration#2: DU with < ND, NU, NG > = <206, 55, 3>* * *Alt 3:*   + *For FR1 with 100MHz channel bandwidth and 30kHz SCS (273 PRB)*     - *SBFD Subband configuration#1: DUD with < ND, NU, NG > = <95, 71, 6>*     - *SBFD Subband configuration#2: DU with < ND, NU, NG > = <196, 71, 6>*   + *For FR2-1 with 200MHz channel bandwidth and 60kHz SCS (264 PRB)*     - *SBFD Subband configuration#1: DUD with < ND, NU, NG > = <95, 68, 3>*     - *SBFD Subband configuration#2: DU with < ND, NU, NG > = <193, 68, 3>* |
| Huawei | ***Proposal 25:*** *Adopt the assumptions for evaluation on Rel-18 NR duplex operation under different deployment scenarios given in Table A.6.* |
| ZTE | ***Proposal 17****: Consider the following configurations for SBFD simulation.*   * *Alt 3 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):*    + *Legacy TDD: Static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U]*   + *SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about ~~[20%]~~ 25 of the channel bandwidth. SBFD Subband configuration#1 with {DUD}={96:69:96} pattern is applied and guard band is 6 RB in each side.* * *Alt 2 (No SBFD DL subband in the slots/symbols that correspond to UL slots/symbols in legacy TDD):*    + *Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]*   + *SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about ~~[20%]~~ 19.4 of the channel bandwidth. SBFD Subband configuration#1 with {DUD}={104:53:104} pattern is applied and guard band is 6 RB in each side.* |
| Samsung | For alternative 3, there are almost 60% DL resource and 40% UL resource in the legacy TDD operation. So, 25% of channel bandwidth can used for UL subband. |
| Qualcomm | ***Observation 7***: Alt 4 and Alt 3 represent fair comparison between SBFD and TDD in terms of DL and UL resources.  ***Proposal 19***: For subband full duplex deployment scenario, support configurable ND RBs DL subbands, NU RBs UL subbands and NG RBs as the gap between the DL and UL subbands   * Option 1: Support ~40% RBs for each of the two DL subbands (ND=2x~40% RBs) and ~20% RBs for UL subband in middle (NU=~20% RBs) and N RBs 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 (ND=NU=entire BW and NG=0) |
| DOCOMO | ***Proposal 4:*** For UL/DL configurations for legacy TDD operation and SBFD operation, Alt 2 should be prioritized for the evaluation. |
| Spreadtrum, BUPT | ***Proposal 14:*** UL subband size should follow the guidance of RAN4 and UL subband could be set to 20% of the channel bandwidth at the first stage. |
| Xiaomi | ***Observation 1:*** For alt 3 and alt 4 under umbrella of SBFD Deployment Case 1,   * It restricts the uplink transmission on the UL symbols with confining available UL resources within UL subband. * The same UL/DL resource ratio between Legacy TDD and SBFD degrades or even eliminate the potential benefits of SBFD. * System performance is further degraded due to the guard band between UL subband and DL subband on UL slot.   ***Proposal 7:*** Dynamic TDD is not used for legacy TDD for comparison. |
| Intel | ***Proposal 9:*** For the agreement related to the time domain allocations for SBFD, the following update should be applied to Alt 3:   * Alt 3 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):   + Legacy TDD: Static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U]   + SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [~~20%~~ 25%] of the channel bandwidth. |
| Dell | ***Proposal 3:*** Consider, as an initial evaluation step, a set of fixed DL-to-UL SBFD ratios or patterns with pre-defined resource locations and guard bands.  ***Proposal 4:*** Consider a set of baseline TDD radio frame formats, corresponding to a set of DL-to-UL offered traffic ratios. |
| KT | ***Observation 1:*** Number of RBs in one guardband can vary according to the frequency range, sub-carrier spacing, and channel bandwidth  ***Proposal 1****: For FR1, NG can be set between 2 to 4 RBs*  ***Proposal 2****: For FR2, NG can be set between 2 to 7 RBs* |
| Ericsson | ***Proposal 24:*** For SBFD evaluations with configuration XXXXU, RAN1 to agree to change the time domain pattern to XXXSU where S includes 2 guard symbols and 12 OFDM symbols in the SBFD slot.  ***Proposal 25:*** RAN1 to agree on the same TDD configurations for performance evaluation of coexistence cases (Case 4) as was agreed for the non-coexistence single operator case (Case 1). |

#### For dynamic/flexible TDD (i.e., TDD UL/DL configuration)

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 32****: For evaluation methodologies for dynamic/flexible TDD, resue SBFD as much as possible, e.g.,*   * *TDD UL/DL configuration and Traffic model:*   + *Consider Table 14 as starting point*   ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.*  Table 14 Slot configurations and ratio of DL/UL traffic for FTP3 for dynamic/flexible TDD.   |  |  | | --- | --- | | **Scenarios** | **Compared cases** | | FR1   * Indoor office * Urban Macro   FR2-1   * Indoor office * Dense Urban Macro layer | * **Legacy deployment**: All TRxPs use DL dominant static TDD operation * {DDDSU}, where S=[12D:2G:0U], ratio of DL/UL traffic = {2:1}, {4:1} or {1:1} * **Flexible TDD deployment**: Each TRxP uses dynamic TDD UL/DL assignment | | FR1   * HetNet with Urban Macro and Indoor office * Dense Urban with 2-layer | * **Legacy deployment**: * Both Macro and Micro/InH TRxP use the same DL dominant static TDD operation   + {DDDSU}, where S=[12D:2G:0U],   + ratio of DL/UL traffic: {4:1} for Macro TRxP; {2:1} or {1:1} for Micro/InH TRxP * **Flexible TDD deployment** : * Option 1: Micro/InH TRxPs use UL dominant static TDD   + {DSUUU}, where S=[12D:2G:0U] * Option 2: Micro/InH TRxPs use dynamic TDD UL/DL assignment | |
| ZTE | ***Proposal 18****: Consider the following slot format traffic model for dynamic TDD simulation.*   |  |  | | --- | --- | | TDD Case | Traffic model | | Legacy TDD  DDDSU, S=[10:2:2] | Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)  - Ratio of DL/UL traffic = {4:1}  - λd/ λu = 0.25/0.0625 or 0.5/0.125 | | Dynamic TDD  DDDSU (Marco)+  DSUUU(small cell)  S=[10:2:2] | Macro: Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)  - Ratio of DL/UL traffic = {4:1}  - λd/ λu = 0.25/0.0625 or 0.5/0.125  Small cell: Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)  - Ratio of DL/UL traffic = {1:4}  - λd/ λu = 0.0625/0.25 or 0.125/0.5 | |
| Qualcomm | ***Proposal 33***: 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) |
| OPPO | ***Proposal 3:*** For dynamic/flexible TDD evaluation, define one non-coexistence deployment case and one coexistence deployment case, each of which runs on single carrier and assumes the same TDD-UL-DL-ConfigCommon across all cells. |
| CATT | ***Proposal 2***: The deployment scenarios for dynamic/flexible TDD evaluation at least include indoor office and heterogeneous deployment with Urban Macro and Indoor office.   * Indoor office with dynamic TDD UL/DL assignment * HetNet with Urban Macro and Indoor office deployed in the same carrier   + Macro layer use DL dominant static TDD UL/DL configuration: {DDDSU}   + Indoor layer use UL dominant static TDD UL/DL configuration: {DSUUU} |
|  |  |

### Summary

In RAN1#109-e meeting, four alternatives were agreed for comparison between baseline legacy TDD operation and SBFD operation under SBFD Deployment Case 1.

|  |
| --- |
| Agreement  For performance evaluation and comparison between baseline legacy TDD operation and SBFD operation under SBFD Deployment Case 1 (Non-coexistence case with single SBFD subband configuration), consider the following alternatives:   * Alt 2 (No SBFD DL subband in the slots/symbols that correspond to UL slots/symbols in legacy TDD):   + Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]   + SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth. * Alt 4 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):   + Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]   + SBFD: Frame structure#3 (XXXXX), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth. * Alt 1 (No SBFD DL subband in the slots/symbols that correspond to UL slots/symbols in legacy TDD):   + Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]   + SBFD: Frame structure#1 (DXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth. * Alt 3 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):   + Legacy TDD: Static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U]   + SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth.   FFS: whether dynamic TDD can optionally be used for legacy TDD for comparison. |

**Ratio of SBFD UL subband over channel bandwidth for Alt 3**

4 companies [ZTE, Samsung, Intel, CMCC] observe that for Alt 3,

* For legacy TDD with static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U], the UL/DL resource ratio for ({DDSUU}, S=[12D:2G:0U]) is about 70%
* While for SBFD with frame structure#2 (XXXXU), and if the SBFD UL subband is about [20%] of the channel bandwidth, the UL/DL resource ratio for ({DDSUU}, S=[12D:2G:0U]) is about 56%

In order to strive for the same UL/DL resource ratio between Legacy TDD and SBFD, the SBFD UL subband is adjusted to about X of the channel bandwidth in Alt3.

* X = 25% [ZTE, Samsung, Intel]
* X = 26% [CMCC]

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Frame structure** | **DL symbol#** | **UL symbol#** | **SBFD (X) symbol#** | **The ratio of SBFD UL subband over channel bandwidth** | **UL/DL resource ratio** |
| **Alt 2** | legacy TDD | DDDSU, S=[12D:2G:0U] | 54 | 14 | 0 |  | 25.9% |
| SBFD | XXXXU |  | 14 | 56 | 20% | 56.3% |
| **Alt 4 (same UL/DL resource ratio)** | legacy TDD | DDDSU, S=[12D:2G:0U] | 54 | 14 | 0 |  | 25.9% |
| SBFD | XXXXX |  | 0 | 70 | 20% | 25.0% |
| **Alt 1** | legacy TDD | DDDSU, S=[12D:2G:0U] | 54 | 14 | 0 |  | 25.9% |
| SBFD | DXXXU | 14 | 14 | 42 | 20% | 47.1% |
| **Alt 3 (same UL/DL resource ratio)** | legacy TDD | DDSUU, S=[12D:2G:0U] | 40 | 28 | 0 |  | 70.0% |
| SBFD | XXXXU | 0 | 14 | 56 | 20% [🡪 26%] | 56.3% [🡪 68.9%] |

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

**SBFD subband configuration**

In RAN1#109-e meeting, two SBFD subband configurations were agreed.

|  |
| --- |
| Agreement  For SBFD evaluation, consider the following for SBFD subband configurations:   * SBFD Subband configuration#1 with {DUD} pattern, which means one SBFD slot consists of one UL subband at the center of the channel bandwidth and two DL subbands at two sides of the channel bandwidth. * SBFD Subband configuration#2 with {DU} pattern, which means one SBFD slot consists of one UL subband at one side of the channel bandwidth and one DL subband at the other side of the channel bandwidth. * Use the following parameters for description of SBFD subband configuration in evaluation assumptions:   + 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 |

 

(a) SBFD Subband configuration#1 with {DUD} pattern (b) SBFD Subband configuration#2 with {DU} pattern

Note that the detailed SBFD DL/UL subband sizes in SBFD symbols for Alt 1/2/3/4 can be determined based on the ratio of SBFD UL subband over channel bandwidth and the guard band sizes.

Regarding the guard band sizes (NG) in each side, the following options are proposed by companies:

* 6 RB for FR1 and 3 RB for FR2-1 [CMCC]
* 6 RB for FR1 and FR2-1 [ZTE]
* 0 RB for FR1 [Qualcomm]
* 2-4 RB for FR1 and 2-7 RB for FR2-1 [KT]
* 3 RB for FR1 and 7 RB for FR2-1 [vivo]
* 14 RB for FR1 [LG]

In moderator’s view, the guard band size (i.e. NG) can be reported by companies for SBFD evaluation. For calibration purpose, we can have simple assumption, e.g., SBFD Subband configuration#1 with {DUD} pattern and NG=5 for both FR1 and FR2-1. Here, we list the corresponding values of {ND, NU,NG} for the 4 alternatives with the assumption that NG=5 for both FR1 and FR2-1, and SBFD UL subband is about [25%] of the channel bandwidth for Alt3. Note that guard symbols are not assumed here.

* Alt 1/2/4:
  + For FR1 with 100MHz channel bandwidth and 30kHz SCS (273 PRB)
    - SBFD Subband configuration#1: DUD with < ND, NU,NG > = <104, 55, 5>
    - SBFD Subband configuration#2: DU with < ND, NU,NG > = <213, 55, 5>
  + For FR2-1 with 200MHz channel bandwidth and 60kHz SCS (264 PRB)
    - SBFD Subband configuration#1: DUD with < ND, NU,NG > = <101, 52, 5>
    - SBFD Subband configuration#2: DU with < ND, NU,NG > = <206, 53, 5>
* Alt 3:
  + For FR1 with 100MHz channel bandwidth and 30kHz SCS (273 PRB)
    - SBFD Subband configuration#1: DUD with < ND, NU,NG > = <97, 69, 5>
    - SBFD Subband configuration#2: DU with < ND, NU,NG > = <199, 69, 5>
  + For FR2-1 with 200MHz channel bandwidth and 60kHz SCS (264 PRB)
    - SBFD Subband configuration#1: DUD with < ND, NU,NG > = <94, 66, 5>
    - SBFD Subband configuration#2: DU with < ND, NU,NG > = <193, 66, 5>

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Frame structure** | **<DL:UL:SBFD (X) > symbol#** | **SBFD configurations** | **< ND, NU, NG >** | **The ratio of SBFD UL subband over channel bandwidth** | **UL/DL resource ratio considering guard band** |
| **Alt 2** | legacy TDD | DDDSU, S=[12D:2G:0U] | <54, 14, 0> |  |  |  | 25.9% |
| SBFD | XXXXU | <0, 14, 56> | DUD for FR1 | <104, 55, 5> | 20.1% | 59.3% |
| DU for FR1 | <213, 55, 5> | 20.1% | 57.9% |
| DUD for FR2-1 | <101, 52, 5> | 19.7% | 59.5% |
| DU for FR2-1 | <206, 53, 5> | 20.1% | 58.9% |
| **Alt 4 (same UL/DL resource ratio)** | legacy TDD | DDDSU, S=[12D:2G:0U] | <54, 14, 0> |  |  |  | 25.9% |
| SBFD | XXXXX | <0, 0, 70> | DUD for FR1 | <104, 55, 5> | 20.1% | 26.4% |
| DU for FR1 | <213, 55, 5> | 20.1% | 25.8% |
| DUD for FR2-1 | <101, 52, 5> | 19.7% | 25.7% |
| DU for FR2-1 | <206, 53, 5> | 20.1% | 25.7% |
| **Alt 1** | legacy TDD | DDDSU, S=[12D:2G:0U] | <54, 14, 0> |  |  |  | 25.9% |
| SBFD | DXXXU | <14, 14, 42> | DUD for FR1 | <104, 55, 5> | 20.1% | 48.8% |
| DU for FR1 | <213, 55, 5> | 20.1% | 48.0% |
| DUD for FR2-1 | <101, 52, 5> | 19.7% | 48.8% |
| DU for FR2-1 | <206, 53, 5> | 20.1% | 48.5% |
| **Alt 3 (same UL/DL resource ratio)** | legacy TDD | DDSUU, S=[12D:2G:0U] | <40, 28, 0> |  |  |  | 70.0% |
| SBFD | XXXXU | <0, 14, 56> | DUD for FR1 | <97, 69, 5> | 25.3% | 70.7% |
| DU for FR1 | <199, 69, 5> | 25.3% | 69.0% |
| DUD for FR2-1 | <94, 66, 5> | 25.0% | 71.4% |
| DU for FR2-1 | <193, 66, 5> | 25.0% | 69.6% |

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

**Others**

Two companies [Ericsson, LG] considers for SBFD evaluations with configuration XXXXU, the time domain pattern should be changed to XXXSU where S includes 2 guard symbols and 12 OFDM symbols in the SBFD slot.

In Moderator’s view, whether guard symbols are needed for SBFD is related to the connection method between TXRUs and panel groups for separate-Tx/Rx antenna array. For example, for method 1-1/1-2, guard symbols may not be needed.



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

### 1st Round Proposals

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

For performance evaluation and comparison between baseline legacy TDD operation and SBFD operation under SBFD Deployment Case 1, make the following update for Alt 3:

* Alt 3 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):
  + Legacy TDD: Static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U]
  + SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about 25% of the channel bandwidth.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | Do we need Alt 3? Wonder if we can just remove Alt 3. |
| Intel | We are OK to revise the text of Alt-3 of this agreement, since clearly the calculation of the percentage of the SBFD UL subbad in respect to the channel bandwidth was wrongly evaluated. |
| Spreadtrum | It’s OK for us, though Alt3 and Alt4 are the second priority. |
| Ericsson | We can support in principle. However, we also think that these alternatives need to be discussed even for Case 4. Furthermore, if UL latency is to be considered as one of the potential gains of SBFD, perhaps DUDDU could be one solution as we proposed in our contribution. |
| New H3C | We are fine with the proposal |

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

For SBFD evaluation, the guard band size (i.e. NG) should be reported by companies.

* For calibration purpose, SBFD Subband configuration#1 with {DUD} pattern and NG=5 is assumed for both FR1 and FR2-1.
  + Alt 1/2/4 (SBFD UL subband is about 20% of the channel bandwidth):
    - For FR1 with 100MHz channel bandwidth and 30kHz SCS (273 PRB): < ND, NU,NG > = <104, 55, 5>
    - For FR2-1 with 200MHz channel bandwidth and 60kHz SCS (264 PRB): < ND, NU,NG > = <101, 52, 5>
  + Alt 3 (SBFD UL subband is about 25% of the channel bandwidth):
    - For FR1 with 100MHz channel bandwidth and 30kHz SCS (273 PRB): < ND, NU,NG > = <97, 69, 5>
    - For FR2-1 with 200MHz channel bandwidth and 60kHz SCS (264 PRB): < ND, NU,NG > = <94, 66, 5>

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | Fine with proposal. |
| Intel | We are Ok with the proposal, and to align on specific frequency domain configurations. Although, in this case the first sentence could be removed. |
| Spreadtrum | Fine with proposal. |
| New H3C | We are fine with the proposal |

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

For SBFD evaluation, companies should report the guard symbols assumed in the SBFD slots

* For calibration purpose, no guard symbol is assumed

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | Fine with proposal |
| Ericsson | We needl to consider guard symbols for SBFD when comparing with Static TDD. |
| New H3C | We are fine with the proposal |

## Issue#2-5: Traffic model

### Submitted proposal

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1****: For SBFD deployment case 1, evaluation assumptions in Table 15 and Table 16 in Annex B can be considered as starting point.*  ***Proposal 19****:* *In SLS for performance evaluation of legacy TDD and SBFD, DL and UL traffic should be simulated simultaneously, and each UE has both UL and DL traffic.*   * *Traffic model in Table 4 is taken as starting point for performance comparison between legacy TDD deployment and SBFD deployment.* * *Packet size for FTP3:*    + *symmetric packet size: 0.5Mbytes for DL/UL (baseline), 0.1Mbytes or 2Mbytes for DL/UL (optional);*   + *asymmetric packet size: 0.5Mbyte for DL and 0.125 Mbytes for UL.*   Table 4 Traffic model for SBFD and dynamic/flexible TDD evaluation.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **Legacy deployment** | | **SBFD deployment** | | | **Deployment case 1** | * **Single operator: Legacy TDD** * **DL arrival rate**: determined according to DL Type-2 RU target, e.g., Low (20%-25%), Medium (40%-50%), High (60%-80%) * **UL arrival rate**: determined by DL arrival rate and Ratio of DL/UL traffic * **Ratio of DL/UL traffic**: {2:1}, {4:1}, {1:1} | | * **Single operator: SBFD** * **DL&UL arrival rate:** same as legacy deployment | | | **Deployment case 4** | * **Operator#1: Legacy TDD** * **DL arrival rate**: determined according to DL Type-2 RU target, e.g., Low (20%-25%), Medium (40%-50%), High (60%-80%) * **UL arrival rate**: determined by DL arrival rate and Ratio of DL/UL traffic * **Ratio of DL/UL traffic**: {4:1} | * **Operator#2: Legacy TDD (**same frame structure as operator#1**)** * **DL arrival rate**: same as **operator**#1 * **UL arrival rate**: determined by DL arrival rate and Ratio of DL/UL traffic * **Ratio of DL/UL traffic**: {2:1}, {4:1}, {1:1}. Independent with operator#1 | * **Operator#1**: Same as operator#1 for legacy **deployment** | * **Operator#2: SBFD** * **DL&UL arrival rate:** same as operator#2 for legacy deployment | | **Deployment case 3-2** | * **Macro layer: Legacy TDD** * **DL arrival rate**: determined according to DL Type-2 RU target, e.g., Low (20%-25%), Medium (40%-50%), High (60%-80%) * **UL arrival rate**: determined by DL arrival rate and Ratio of DL/UL traffic * **Ratio of DL/UL traffic**: {4:1} | * **Micro/InH layer: Legacy TDD(**same frame structure as Macro layer**)** * **DL arrival rate**: same as Macro layer * **UL arrival rate**: determined by DL arrival rate and Ratio of DL/UL traffic * **Ratio of DL/UL traffic**: {2:1}, {4:1}, {1:1}. Independent with Macro layer | * **Macro layer:** same as Macro layer for legacy deployment | * **Micro/InH layer: SBFD** * **DL&UL arrival rate:** same as Micro/InH layer for legacy deployment |   ***Proposal 32****: For evaluation methodologies for dynamic/flexible TDD, resue SBFD as much as possible, e.g.,*   * *Performance metrics used for evaluation of SBFD can also be used for evaluation of dynamic/flexible TDD except the SBFD-specific metrics.* * ***TDD UL/DL configuration and Traffic model:***   + ***Consider Table 14 as starting point***   + ***Packet size for FTP3:***      - ***symmetric packet size: 0.5Mbytes for DL/UL (baseline), 0.1Mbytes or 2Mbytes for DL/UL (optional);***     - ***asymmetric packet size: 0.5Mbyte for DL and 0.125 Mbytes for UL.***   + ***For legacy TDD deployment,***      - ***the DL arrival rate is determined according to DL Type-2 RU target, e.g., Low (20%-25%), Medium (40%-50%), High (60%-80%).***     - ***The UL arrival rate is determined by DL arrival rate and Ratio of DL/UL traffic.***   + ***For dynamic/flexible TDD deployment, adopt the same DL and UL arrival rate as legacy TDD deployment.*** * *Antenna configuration:*    + *For BS antenna array configuration: Legacy TDD configuration in Table 6 can be considered*   + *For BS Antenna radiation pattern, UE antenna array configuration and UE antenna radiation pattern, reuse the assumptions for SBFD* * *BS transmit power: Table 13 is considered.*   ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.*  Table 14 Slot configurations and ratio of DL/UL traffic for FTP3 for dynamic/flexible TDD.   |  |  | | --- | --- | | **Scenarios** | **Compared cases** | | FR1   * Indoor office * Urban Macro   FR2-1   * Indoor office * Dense Urban Macro layer | * **Legacy deployment**: All TRxPs use DL dominant static TDD operation * {DDDSU}, where S=[12D:2G:0U], ratio of DL/UL traffic = {2:1}, {4:1} or {1:1} * **Flexible TDD deployment**: Each TRxP uses dynamic TDD UL/DL assignment | | FR1   * HetNet with Urban Macro and Indoor office * Dense Urban with 2-layer | * **Legacy deployment**: * Both Macro and Micro/InH TRxP use the same DL dominant static TDD operation   + {DDDSU}, where S=[12D:2G:0U],   + ratio of DL/UL traffic: {4:1} for Macro TRxP; {2:1} or {1:1} for Micro/InH TRxP * **Flexible TDD deployment** : * Option 1: Micro/InH TRxPs use UL dominant static TDD   + {DSUUU}, where S=[12D:2G:0U] * Option 2: Micro/InH TRxPs use dynamic TDD UL/DL assignment | |
| Huawei | ***Proposal 21:*** *Adopt the traffic model for evaluation on Urban Macro, Dense Urban Macro layer and indoor office in Table A.3.*   * *Each UE has both UL and DL traffic. DL and UL are simulated simultaneously.* * *FTP packet size is 0.1, 0.5 and 2.0Mbytes.* * *FTP packet arrival rate is obtained as following steps:*   + *Step 1: Determine FTP packet arrival rate for legacy TDD.*     - *Step 1-1: The DL arrival rate is selected to reach a target DL RU, e.g., low DL RU (20%-25%), medium DL RU (40%-50%), and high DL RU (60%-80%).*     - *Step -2: The UL arrival rate is determined by the ratio of DL/UL traffic, e.g., DL:UL = {1:1}, {2:1}, and {4:1}.*   + *Step 2: The UL and DL FTP packet arrival rate for SBFD are the same as legacy TDD.*   ***Proposal 22:*** *Adopt the traffic model for evaluation for HetNet scenario in Table A.3.*   * *Each UE has both UL and DL traffic. UL and DL are simulated simultaneously.* * *FTP packet size is 0.1, 0.5 and 2.0Mbytes.* * *FTP packet arrival rate is obtained as following steps:*   + *Step 1: Determine FTP packet arrival rate for legacy TDD.*     - *Step 1-1: The DL arrival rate#1 of Macro cell and DL arrival rate#2 of Pico cell are selected to reach target DL RU#1 of Macro cell and target DL RU#2 of Macro cell, respectively, e.g., medium DL RU#1 and DL RU#2 (40%-50%), and high DL RU#1 and high DL RU#1 (60%-80%).*     - *Step 1-2: The UL arrival rate#1 is determined by the DL arrival rate#1 and ratio of DL/UL traffic, e.g., DL:UL = {1:1}, {2:1}, and {4:1}. Similarly, UL arrival rate#2 is determined by the DL arrival rate#2 and ratio of DL/UL traffic, e.g., DL:UL = {1:1}, {2:1}, and {4:1}.*   + *Step 2: The UL and DL FTP packet arrival rate for SBFD and dynamic/flexible TDD are the same as legacy TDD.* |
| ZTE | ***Proposal 14:*** *Consider the following traffic model for SBFD simulation.*  *Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)*  *- Ratio of DL/UL traffic = {2:1}, {4:1} and {1: 1} [TR36.828]*  *- per UE λd/ λu is determined based on the RU, e.g., 5/2.5 2.5/1.25 2.5/0.8*  ***Proposal 18****: Consider the following slot format traffic model for dynamic TDD simulation.*   |  |  | | --- | --- | | TDD Case | Traffic model | | Legacy TDD  DDDSU, S=[10:2:2] | Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)  - Ratio of DL/UL traffic = {4:1}  - λd/ λu = 0.25/0.0625 or 0.5/0.125 | | Dynamic TDD  DDDSU (Marco)+  DSUUU(small cell)  S=[10:2:2] | Macro: Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)  - Ratio of DL/UL traffic = {4:1}  - λd/ λu = 0.25/0.0625 or 0.5/0.125  Small cell: Burst buffer with FTP traffic model 3 (packet size = 0.1, 0.5, and 2.0 MB)  - Ratio of DL/UL traffic = {1:4}  - λd/ λu = 0.0625/0.25 or 0.125/0.5 | |
| Ericsson | ***Proposal 18:*** RAN1 to agree that the traffic load in system level simulations is based on an aggregated system resource utilization between UL and DL based on the reference static TDD network 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 link direction.  ***Proposal 19:*** RAN1 to agree traffic loads that yield aggregated resource utilizations of below 10%, 25-35%, and above 55% for Low load, medium load, and High load in the reference static TDD system, respectively.  ***Proposal 20:*** For co-existence evaluations (e.g. between two networks), further consider high input traffic in the aggressor network and low in the victim network.  The reason is that in case of high load on both networks, it would be challenging to identify if the potential disruption of performance is due to the interference generated internally by the victim networks, or by the aggressor network. |
| Samsung | ***Proposal 11:*** *For the traffic model, we suggest*   * *Other traffic models: It is enough to use FTP3 as mandatory. Not use XR and VoIP traffic model as mandatory* * *Packet size: Support DL/UL symmetric/asymmetric packet size*   + *Symmetric packet size: 0.5Mbytes for DL/UL (baseline), 0.1Mbytes or 2Mbytes (optional)*   + *Asymmetric packet size: 0.5Mbyte for DL and 0.125 Mbytes for UL* * *Traffic load (resource utilization): Support DL/UL symmetric/asymmetric traffic load*   + *Symmetric traffic load: 20, 50, 80% for DL/UL (baseline)*   + *Asymmetric traffic load: (DL:UL) = (80%, 20%)*   ***Proposal 12:*** RAN1 takes the parameters for duplex evolution in Table 7. |
| Qualcomm | ***Proposal 14:*** For subband full duplex evaluation, low (<10%), medium (20%) and high (40-50%) traffic load could be assumed based on target resource utilization.   * Each UE is either assigned UL traffic or DL traffic. * Different packet size should be considered * Separate DL/UL target resource utilization. |
| vivo | ***Proposal 4***: 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 | |
| OPPO | ***Proposal 2***: The ratio of combined traffic volumes over FTP3 arrival rate and packet size between uplink and downlink should reflect the semi-static resource amount ratio between uplink and downlink. The downlink-to-uplink traffic volume ratio of 4:1 can be used given the TDD U/D configuration of “DDDSU”. |
| CATT | ***Proposal 4:*** Evaluate low, medium and high RU ratios (20%, 50% and 80%) via different packet arrival rates in SBFD system evaluation. |
| Nokia, Nokia Shanghai Bell | ***Proposal 11:*** For the traffic models for dynamic/flexible TDD and SBFD evaluations, consider FTP3 traffic as   * For FTP3 traffic:   + Assume payload sizes of at least 200-1500 Bytes (small packet) and 0.5 Mbytes (large packet).   + Assume the ratio of DL:UL traffic to be fixed to 2:1 (other values are not precluded)   + Arrival rate is selected to reach a certain PRB resource utilization target, e.g. 10% (low load) and 60% (high load). The legacy static TDD is selected as the baseline case for determining the arrival rate.     - FFS: the definition of the resource utilization. |
| LG | ***Proposal 3:*** *For SBFD evaluation, FTP3 with small packet size and small traffic load is prioritized.* |
| Spreadtrum, BUPT | ***Proposal 11:*** Packet size, traffic load, ratio of DL/UL traffic listed in Table 6 should be adopted in simulation.  ***Proposal 12:*** Low prioritize other traffic models, e.g., XR, VoIP  ***Proposal 13:*** Different amount of input traffic for adjacent-channel coexistence should be studied at the second stage.  **Table 6**: **Traffic model parameters**   |  |  | | --- | --- | | Traffic Model | * FTP traffic model 3   + Packet size: 0.1，0.5，2 Mbyte   + Traffic load: 25%, 50% and 80%   + 𝜆DL:𝜆𝑈L= 4:1/2:3 | |
| Xiaomi | Considering the objective of SBFD, it is not the suitable technique for VoIP which can be supported pretty well by nowadays mechanism.  ***Proposal 4:*** XR traffic models can be considered for SBFD and dynamic/flexible TDD evaluation.  ***Proposal 5:*** The following principle should be used when we determine the parameters associated with FTP model 3:   * Packet size equals to 0.5Mbytes which is the typical value defined in TR36.814 * Packet arrival rate within value range [0.5, 1, 1.5, 2, 2.5] to can be a starting point * Traffic load can be determined by packet arrival rate |
| Intel | ***Proposal 7:*** Regarding the baseline assumptions for the FTP3 traffic model:   * Different levels of loading in each duplex direction (DL/UL) are considered, including 20%, 40%, 60%, and 80% * Different values of DL:UL traffic ratio are studied, including 4:1 and 2:1. * The packet size is fixed to 0.1 MB. |
| Dell | ***Proposal 5:*** Consider FTP3 traffic model in both DL and UL directions, with pre-determined packet sizes and average arrival rates. |
|  |  |

### Summary

Regarding the traffic model of FTP model 3 for scenarios in deployment case 1 for SBFD evaluation, moderator suggests **Initial proposal 2-5-1** based on the submitted proposals.

The traffic model for other deployment cases for SBFD evaluation and the traffic model for dynamic/flexible TDD evaluation can be discussed later after we have conclusion on this proposal.

### 1st Round Proposals

#### ***Initial proposal 2-5-1:***

Adopt the following table for traffic model of FTP model 3 for scenarios in deployment case 1 for SBFD.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Indoor office (FR1&FR2) | Urban Macro (FR1) | Dense Urban Macro layer (FR1&FR2) | Dense Urban Micro layer (FR2) | Dense Urban with 2-layer (FR1) |
| General | UL and DL are simulated simultaneously. Option 1 is used.   * Option 1: Each UE is assigned both UL traffic and DL traffic. * Option 2: Each UE is either assigned UL traffic or DL traffic. | | | | |
| FTP packet size | Both symmetric and asymmetric packet size for UL and DL can be considered.   * Option 1: Symmetric packet size: 0.5Mbytes for DL/UL (baseline), 0.1Mbytes or 2Mbytes for DL/UL (optional)   + FFS: 1Kbyte for DL/UL * Option 2: Asymmetric packet size: 0.5Mbyte for DL and 0.125 Mbytes for UL.   + FFS: 1Kbyte for UL | | | | |
| DL arrival rate for legacy TDD | * The DL arrival rate is selected to reach a target DL traffic load (RU). * DL Traffic load: low DL RU (20%-25%), medium DL RU (40%-50%), and high DL RU (60%-80%). * Note: Type-2 RU definition (calculated per link direction) is used | | | | * The DL arrival rate#1 of Macro cell and DL arrival rate#2 of Micro cell are selected to reach target DL traffic load (RU)#1 of Macro cell and target DL traffic load (RU)#2 of Micro cell, respectively * DL Traffic load: low DL RU (20%-25%), medium DL RU (40%-50%), and high DL RU (60%-80%). * Note: Type-2 RU definition (calculated per link direction) is used |
| UL arrival rate for legacy TDD | * The UL arrival rate is determined by the ratio of DL/UL traffic * Ratio of DL/UL traffic: {2:1}, {4:1}, {1:1} | | | | * The UL arrival rate#1 is determined by the DL arrival rate#1 and ratio of DL/UL traffic of Macro cell. UL arrival rate#2 is determined by the DL arrival rate#2 and ratio of DL/UL traffic of Micro cell * Ratio of DL/UL traffic: {2:1}, {4:1}, {1:1}. |
| Arrival rate for SBFD | The UL and DL FTP packet arrival rate for SBFD are the same as legacy TDD. | | | | |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | We are generally OK with the proposal. However,   * In the “general” row, while our preference is for option 2, and that for each slot a UE should be either associated with DL or UL traffic, this could be left up to companies to decide based on their on implementation.   For FTP packet size, symmetric traffic with smaller packet size could be used a a baseline to reduce simulation run time, and other packet sizes and asymmetric traffic could be optionally considered. |
| Spreadtrum | We prefer option 1 in general. About ratio of DL/UL traffic, we think it can be listed for Symmetric packet size and Asymmetric packet size, respectively. |
| New H3C | We are fine with the proposal |

## Issue#2-6: Antenna configurations

### Submitted proposal

#### For SBFD

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1****: For SBFD deployment case 1, evaluation assumptions in Table 15 and Table 16 in Annex B can be considered as starting point.*  **Separate-Tx/Rx antenna array modelling for SBFD**  ***Proposal 20****:* *For evaluation of SBFD operation, separate-Tx/Rx antenna array can be modelled by two panel groups.*   * *Each panel group comprises panels. For each panel group, antenna panels are uniformly spaced in the horizontal and vertical direction. On each antenna panel, antenna elements are uniformly spaced in the vertical and horizontal direction.* * *Legacy parameters , and are used for description of each panel group:*   + *: Number of panels in a column within a panel group.*   + *: Number of panels in a row within a panel group.*   + *: Antenna panel spacing in horizontal direction within a panel group.*   + *: Antenna panel spacing in vertical direction within a panel group.* * *Introduce additional parameters and for description of the total number of vertical TXRUs across two panel groups and panel group spacings:*   + *: Total number of vertical TXRUs across two panel groups, on one polarization.*   + *: Total number of horizontal TXRUs across two panel groups, on one polarization.*   + *: Panel group spacing in the horizontal direction. Typically, = 0.*   + *: Panel group spacing in the vertical direction.*     Figure 9 Separate-Tx/Rx antenna array for SBFD.  **BS antenna array configuration**  ***Proposal 21****: For evaluation of SBFD operation, BS antenna configurations in Table 6 can be considered for calibration.*  **Table** 6 **Typical antenna configurations for InH BS and Macro/Micro BS.**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Scenarios** | **FR** | **Legacy TDD** | **SBFD** | | |  |  |  | **Opt 1 (Example 1-1/1-2/1-3)** | **Opt 2 (Example 2-1/2-2)** | | **InH**  **BS antenna cfg.** | FR1 | **Baseline**:= (2,1,2,1,1; 2,1) | =(1,1,2,1,1) | =(2,1,2,1,1) | |  |  | **Optional**: = (4,4,2,1,1; 4,4) | =(2,4,2,1,1) | = (4,4,2,1,1) | |  |  | = (0.5, 0.5)λ, +45°, -45° polarization, (da,H,da,V) = (N/A, 4)λ | | | |  | FR2-1 | =  (4,8,2,1,1; 4,4) | =(2,8,2,1,1) | =(4,8,2,1,1) | |  |  | = (0.5, 0.8)λ, +45°, -45° polarization, (da,H,da,V) = (N/A, 30)λ | | | | **Macro/Micro**  **BS antenna cfg.** | FR1 | =  (8,8,2,1,1;2,8) | =(4,8,2,1,1) | =(8,8,2,1,1) | |  |  | = (0.5, 0.8)λ, +45°, -45° polarization, (da,H,da,V) = (N/A, 4)λ | | | |  | FR2-1 | =  (4,8,2,2,2; 1,1) | =(4,8,2,1,2) | =(4,8,2,2,2) | |  |  | = (0.5, 0.5)λ; = (4.0, 2.0)λ; +45°, -45° polarization, (da,H,da,V) = (N/A, 30)λ | | |   Note: 4 *λ* for FR1 (4GHz) and 30 *λ* for FR2-1 (30GHz) are both equal to 30cm.    (a) Legacy TDD (b) SBFD Example 1-1 (c) SBFD Example 1-2    (d) SBFD Example 1-3 (e) SBFD Example 2-1 (f) SBFD Example 2-2  Figure 10 Connection example for legacy TDD and SBFD.  **BS Antenna radiation pattern**  ***Proposal 22****: For evaluation of SBFD operation, consider BS Antenna radiation pattern as following,*   * *InH: Table 10 in Report ITU-R M.2412* * *Urban Macro/ Dense Urban Macro layer / Dense Urban Micro layer: Table 9 in Report ITU-R M.24123-sector BS antenna radiation model in Table A.2.1-6 in TR 38.802*   **UE antenna configuration**  ***Proposal 23****:* *For evaluation of SBFD operation, consider UE antenna configuration as following,*   * *FR1:*    + *2Tx: (M,N,P,Mg,Ng;Mp,Np) = (1,1,2,1,1;1,1), (dH,dV) = (N/A, N/A)λ, 0°,90° polarization*   + *4Rx: (M,N,P,Mg,Ng;Mp,Np) = (1,2,2,1,1;1,2), (dH,dV) = (0.5, N/A)λ, 0°,90° polarization* * *FR2-1:*    + *4Tx/Rx: (M,N,P,Mg,Ng;Mp,Np) = (2, 4, 2, 1, 2; 1, 1); (dH,dV) = (0.5, 0.5)λ,(dg,V,dg,H) = (0, 0)λ, 0°,90° polarization*   **UE antenna radiation pattern**  ***Proposal 24****:* *For evaluation of SBFD operation, consider UE antenna radiation pattern as following,*   * *FR1: Omni-directional with 0 dBi element gain* * *FR2: UE antenna radiation pattern model 1 in Table A.2.1-8 in TR 38.802*   *For dynamic/flexible TDD*  ***Proposal 32****: For evaluation methodologies for dynamic/flexible TDD, resue SBFD as much as possible, e.g.,*   * *Antenna configuration:*    + *For BS antenna array configuration: Legacy TDD configuration in Table 6 can be considered*   + *For BS Antenna radiation pattern, UE antenna array configuration and UE antenna radiation pattern, reuse the assumptions for SBFD*   ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.*  ***Proposal 32****: For evaluation methodologies for dynamic/flexible TDD, resue SBFD as much as possible, e.g.,*   * ***TDD UL/DL configuration and Traffic model:***   + ***Consider Table 14 as starting point***   + *Packet size for FTP3:*      - *symmetric packet size: 0.5Mbytes for DL/UL (baseline), 0.1Mbytes or 2Mbytes for DL/UL (optional);*     - *asymmetric packet size: 0.5Mbyte for DL and 0.125 Mbytes for UL.*   + *For legacy TDD deployment,*      - *the DL arrival rate is determined according to DL Type-2 RU target, e.g., Low (20%-25%), Medium (40%-50%), High (60%-80%).*     - *The UL arrival rate is determined by DL arrival rate and Ratio of DL/UL traffic.*   + *For dynamic/flexible TDD deployment, adopt the same DL and UL arrival rate as legacy TDD deployment.*   ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.* |
| Huawei | **BS antenna array configuration**  ***Proposal 23:*** *Adopt the antenna configurations in Table A.4-1 to Table A.4-4 at both sides of TRxP and UE for evaluation on Rel-18 NR duplex operation.*   * *For legacy TDD, only one antenna array with antenna elements, Tx chains and Rx chains is considered.* * *In DL slots, antenna elements on antenna array are connected to Tx chains.* * *In UL slots, antenna elements on antenna array are connected to Rx chains.* * *For Opt 1, two separate antenna arrays and two TxRU groups are considered, where each antenna array has antenna elements and each TxRU group has Tx chains and Rx chains.* * *In DL slots, antenna elements on antenna array#1 are connected to Tx chains in TxRU group#1, and antenna elements on antenna array#2 are connected to Tx chains in TxRU group#2.* * *In UL slots, antenna elements on antenna array#1 are connected to Rx chains in TxRU group#1, and antenna elements on antenna array#2 are connected to Rx chains in TxRU group#2.* * *In SBFD slot, antenna elements on antenna array#1 are connected to Tx chains in TxRU group#1, and antenna elements on antenna array#2 are connected to Rx chains in TxRU group#2.* * *For Opt 2, two separate antenna arrays and only one TxRU group are considered, where each antenna array has antenna elements and the TxRU group includes Tx chains and Rx chains.*   + *In DL slots, antenna elements on antenna array#1 are connected to Tx chains.*   + *In UL slots, antenna elements on antenna array#1 are connected to Rx chains.*   + *In SBFD slots, antenna elements on antenna array#1 are connected to Tx chains and antenna elements on antenna array#2 are connected to Rx chains.*       Fig. 7 Antenna configuration for Opt 1 of SBFD.      Fig. 8 Antenna configuration for Opt 2 of SBFD. |
| ZTE | ***Proposal 15****: Update the previous agreements as following.*   |  | | --- | | **Agreement**  For evaluation and comparison between SBFD and legacy TDD, assume the total number of TxRUs of the antenna array for SBFD is the same as the total number of TxRUs of the antenna array for legacy TDD. Regarding antenna elements, both of the two options can be used.   * Opt 1: The total number of antenna elements of the antenna array for SBFD (N) is the same as the total number of antenna elements of the antenna array for legacy TDD. * Alt.1-1: during the legacy DL slot or UL slot, all the N antenna elements can be used for transmission or reception, respectively. During the SBFD slot, N/2 antenna elements are used for transmission and reception, respectively. * Alt.1-2: during the legacy DL slot or UL slot, only N/2 antenna elements can be used for transmission or reception, respectively. During the SBFD slot, N/2 antenna elements are used for transmission and reception, respectively. * Opt 2: The total number of antenna elements of the antenna array for SBFD is two times of the total number of antenna elements of the antenna array for legacy TDD.   Companies report which option is assumed in their simulation. | |
| Ericsson | ***Observation 10***: For real deployments of SBFD network, the TxRUs are more complicated than the TxRUs in static TDD network.  ***Proposal 21:*** RAN1 to agree that for system level evaluations, the number of TxRUs for SBFD network could be different from the number of TxRUs for Static TDD network. |
| Samsung | ***Proposal 9:*** *Consider to following two antenna modes for non-SBFD symbol(s)/slot(s)*   * *Mode 1: All antenna elements are used for DL transmission or UL reception*   + *FFS: whether to introduce additional gap symbols between a SBFD symbol and DL-only symbol or between a SBFD symbol and UL-only symbol* * *Mode 2: Antenna elements same as SBFD symbol(s)/slot(s) are used for DL transmission or UL reception*   ***Proposal 10:*** For evaluation, RAN1 takes the parameters for BS antenna configurations shown in Table 6 as a starting point.  **Table 6. BS antenna configuration**   |  |  | | --- | --- | | **Deployment scenarios** | **BS antenna configuration (M,N,P,Mg,Ng)** | | **Indoor hotspot** | FR1,  - static TDD : (4,4,2,1,1)  - SBFD :  < Mode 1 + Opt 1>  (2,4,2,1,1) for SBFD symbols, (4,4,2,1,1) for non-SBFD symbols  < Mode 1 + Opt 2>  (4,4,2,1,1) for SBFD symbols, (8,4,2,1,1) for non-SBFD symbols  < Mode 2 + Opt 1>  (2,4,2,1,1) for all symbols,  < Mode 2 + Opt 2>  (4,4,2,1,1) for all symbols,  - dynamic/flexible TDD: same as static TDD  FR2,  - TDD : (4,8,2,1,1)  - SBFD :  < Mode 1 + Opt 1>  (4,4,2,1,1) for SBFD symbols, (4,8,2,1,1) for non-SBFD symbols  < Mode 1 + Opt 2>  (4,8,2,1,1) for SBFD symbols, (8,8,2,1,1) for non-SBFD symbols  < Mode 2 + Opt 1>  (4,4,2,1,1) for all symbols,  < Mode 2 + Opt 2>  (4,8,2,1,1) for all symbols  - dynamic/flexible TDD: same as static TDD | | **Dense Urban/Urban Macro** | FR1,  - static TDD : (8,8,2,1,1)  - SBFD :  < Mode 1 + Opt 1>  (8,4,2,1,1) for SBFD symbols, (8,8,2,1,1) for non-SBFD symbols  < Mode 1 + Opt 2>  (8,8,2,1,1) for SBFD symbols, (8,16,2,1,1) for non-SBFD symbols  < Mode 2 + Opt 1>  (8,4,2,1,1) for all symbols,  < Mode 2 + Opt 2>  (8,8,2,1,1) for all symbols,  - dynamic/flexible TDD: same as static TDD  FR2,  - TDD : (8,16,2,1,1)  - SBFD :  < Mode 1 + Opt 1>  (8,8,2,1,1) for SBFD symbols, (8,16,2,1,1) for non-SBFD symbols  < Mode 1 + Opt 2>  (8,16,2,1,1) for SBFD symbols, (16,16,2,1,1) for non-SBFD symbols  < Mode 2 + Opt 1>  (8,8,2,1,1) for all symbols,  < Mode 2 + Opt 2>  (8,16,2,1,1) for all symbols,  - dynamic/flexible TDD: same as static TDD |   Note1: (dH,dV)=(0.5,0.8)λ for FR1, (dH,dV)=(0.5,0.5)λ for FR2 |
| Qualcomm | ***Proposal 15:*** For both options of SBFD BS antenna configurations, at least the transmit panel in SBFD slot should be switchable to Rx mode to enable full DL/UL channel reciprocity.    ***Proposal 16***: Adopt the gNB antenna configuration in Table-4 and Table 5.  **Table 4 Antenna Configuration for FR1**   |  |  |  |  | | --- | --- | --- | --- | |  | **UMa** | **UMi** | **Indoor Hotspot** | | gNB antenna configuration (Option 1) | (M,N,P,Mg,Ng,Mp,Np,dV,dH)  (4,16, 2, 1, 1, 2,16, 0.8, 0.5).  64 ports (32 Tx +32 Rx) | | (M,N,P,Mg,Ng,Mp,Np,dV,dH)  (4, 4, 2, 1, 1, 4, 4, 0.5, 0.5).  32 ports (16 Tx + 16 Rx) | | gNB antenna configuration (Option 2) | (M,N,P,Mg,Ng,Mp,Np,dV,dH)  (8,16, 2, 1, 1, 4,16, 0.8, 0.5).  128 ports (64 Tx +64 Rx) | | (M,N,P,Mg,Ng,Mp,Np,dV,dH)  (8, 4, 2, 2, 1, 8, 4, 0.5, 0.5).  64 ports (32 Tx + 32 Rx) | | gNB antenna configuration (TDD) | (M,N,P,Mg,Ng,Mp,Np,dV,dH)=(4,16, 2, 1, 1, 2,16, 0.8, 0.5). 64 ports/TxRu | | (M,N,P,Mg,Ng,Mp,Np,dV,dH)=(4, 4, 2, 1, 1, 4, 4, 0.5, 0.5). 32 ports |   **Table 5 Antenna Configuration for FR2**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | Parameter | **Deployment scenarios** | | | | | **UMa (38.913 w/ following parameters)**  **200 ISD** | **UMi (38.913 w/ following parameters)**  **100 ISD** | **Indoor Hotspot**  **(38.913 w/ following parameters)**  **FR2-1** | **Indoor Hotspot**  **(38.913 w/ following parameters)**  **FR2-2** | | Antenna Configurations | FD: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)  TDD: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (4,16,2,2,2;1,1)  (dH, dV) = (0.5λ, 0.5λ) | | FD: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (8, 8, 2,1,1;1,1)  TDD: 2 TxRU, (M, N, P, Mg, Ng; Mp, Np) = (16, 8, 2,1,1;1,1)   (dH, dV) = (0.5λ, 0.5λ) | |   ***Observation 6***: 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 17***: 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.  *For dynamic/flexible TDD,*  ***Proposal 33***: 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 34***: 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. |
| Xiaomi | ***Proposal 9:*** For SBFD simulation, separate Tx/Rx antenna array should be assumed for simultaneous transmission and reception.  ***Proposal 10:*** For SBFD simulation, 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. |
| Sharp | ***Proposal 1:*** For Indoor office scenario, {M,N,P} = {4,4,2} is the baseline assumption for TRxP antenna configuration. The number of antenna panels could be more than 1.  ***Proposal 2:*** For Indoor office scenario, the number of antenna elements could be 4 or larger. If RedCap UE should be included in the scope of the duplex study, we can consider 2 as well.  ***Proposal 3:*** For Indoor office scenario, BS antenna pattern is , and the maximum gain = 5 dBi.  ***Proposal 4***: Detailed design on electric tilt as well as gNB antenna configuration can be up to companies to report. |
| Kumu | ***Observation 1:*** Simply using separate antennas on adjacent frequencies provides insufficient isolation for FR1  ***Observation 2:*** Beamforming Gain may be compromised when beam nulling techniques are used to improve isolation.  ***Observation 3:*** For FR1 Massive MIMO base-stations in particular, using spatial nulling for subband full duplex without simultaneously maintaining beamforming gain nearly eliminates the coverage enhancement benefits of Massive MIMO base-stations. This is a serious drawback since one of the main drivers for FR1 Massive MIMO adoption is the higher beamforming gain used to “claw back” coverage and range. Please see appendix for explanation.  ***Proposal 1:*** Beamforming gain should be considered together with the antenna isolation used in the evaluation methodology and simulation results.  ***Proposal 2:*** For subband full duplex deployment scenario, BS antenna configuration shall consider the inclusion of RF self-interference cancellation thus allowing systems to maintain high electrical isolation between transmit and receive antennas while not needing additional spatial isolation  ***Proposal 3:*** For FRI Massive MIMO deployment scenarios using subband full duplex, BS antenna configuration shall support the inclusion of RF self-interference cancellation thus maintaining Massive MIMO coverage enhancement and beamforming gain even when beamnulling is used to improve transmit – receive isolation. |
|  |  |

### Summary

Regarding the details of separate-Tx/Rx antenna array of SBFD operation, moderator suggests **Initial proposal 2-6-1 and 2-6-2** based on the submitted proposals.

Regarding BS antenna radiation pattern, moderator suggests **Initial proposal 2-6-3** based on the submitted proposals.

Regarding UE antenna radiation pattern, moderator suggests **Initial proposal 2-6-4** based on the submitted proposals.

Regarding BS antenna configuration, moderator suggests **Initial proposal 2-6-5** based on the submitted proposals.

Regarding UE antenna configuration, moderator suggests **Initial proposal 2-6-6** based on the submitted proposals.

### 1st Round Proposals

#### ***Initial proposal 2-6-1:***

For evaluation of SBFD operation, separate-Tx/Rx antenna array can be modelled by two panel groups.

* Legacy parameters , and are used for description of each panel group:
  + M: Number of vertical antenna elements within a panel, on one polarization
  + N: Number of horizontal antenna elements within a panel, on one polarization
  + P: Number of polarizations
  + : Number of panels in a column within a panel group.
  + : Number of panels in a row within a panel group.
  + : Antenna panel spacing in horizontal direction within a panel group.
  + : Antenna panel spacing in vertical direction within a panel group.
* Companies report the separation of the two panel groups. Introduce new parameters as illustrated in the following figure.
  + : Panel group spacing in the horizontal direction. Typically, = 0.
  + : Panel group spacing in the vertical direction.



Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Ericsson | We support the proposal |
| New H3C | We are fine with the proposal |
|  |  |

#### ***Initial proposal 2-6-2:***

For evaluation and comparison between SBFD and legacy TDD, the two options for the SBFD antenna configuration agreed in RAN1#109 are further clarified as below:

* **SBFD antenna configuration option-1** (same as Opt 1 in RAN1#109 agreement): The total number of antenna elements of the antenna array for SBFD is the same as the total number of antenna elements of the antenna array for legacy TDD. The total number of TxRUs of the antenna array for SBFD is the same as the total number of TxRUs of the antenna array for legacy TDD.
* **SBFD antenna configuration option-2** (same as Opt 2 in RAN1#109 agreement): The total number of antenna elements of the antenna array for SBFD is two times of the total number of antenna elements of the antenna array for legacy TDD. The total number of TxRUs of the antenna array for SBFD is the same as the total number of TxRUs of the antenna array for legacy TDD.
* **SBFD antenna configuration option-3** (new): The total number of antenna elements of the antenna array for SBFD is the same as the total number of antenna elements of the antenna array for legacy TDD. The total number of TxRUs of the antenna array for SBFD is half of the total number of TxRUs of the antenna array for legacy TDD.

These options are further clarified with examples in the following:

* For legacy TDD with shared-Tx/Rx antenna array, assume the antenna configuration is . The total number of TxRUs is , and the total number of antenna elements is .



* For SBFD antenna configuration option-1, the separate-Tx/Rx antenna array has two panel groups, and the antenna configuration for each panel group is . The total number of TXRUs is (same as legacy TDD), and the total number of antenna elements is (same as legacy TDD). One method on the usage of TXRUs and antenna elements in DL/UL/SBFD slots/symbols is illustrated as below. Other methods are not precluded and can be reported by companies.
  + Method 1:
    - In DL slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Tx chains in TxRU group#1, and L⁄2 antenna elements on panel group#2 are connected to K⁄2 Tx chains in TxRU group#2.
    - In UL slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Rx chains in TxRU group#1, and L⁄2 antenna elements on panel group#2 are connected to K⁄2 Rx chains in TxRU group#2.
    - In SBFD slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Tx chains in TxRU group#1, and L⁄2 antenna elements on panel group#2 are connected to K⁄2 Rx chains in TxRU group#2.



* For SBFD antenna configuration option-2, the separate-Tx/Rx antenna array has two panel groups, and the antenna configuration for each panel group is . The total number of TXRUs is (same as legacy TDD), and the total number of antenna elements is (two times of that for legacy TDD). Two methods on the usage of TXRUs and antenna elements in DL/UL/SBFD slots/symbols are illustrated as below. Other methods are not precluded and can be reported by companies.
  + Method 2-1:
    - In DL slots, L antenna elements on panel group#1 are connected to K Tx chains.
    - In UL slots, L antenna elements on panel group#2 are connected to K Rx chains.
    - In SBFD slots, L antenna elements on panel group#1 are connected to K Tx chains, and L antenna elements on panel group#2 are connected to K Rx chains.



* + Method 2-2:
    - In DL slots, L antenna elements on panel group#1 are connected to K Tx chains.
    - In UL slots, L antenna elements on panel group#1 are connected to K Rx chains.
    - In SBFD slots, L antenna elements on panel group#1 are connected to K Tx chains, and L antenna elements on panel group#2 are connected to K Rx chains.



* For SBFD antenna configuration option-3, the separate-Tx/Rx antenna array has two panel groups, and the antenna configuration for each panel group is . The total number of TXRUs is (half of that for legacy TDD), and the total number of antenna elements is (same as legacy TDD). The method on the usage of TXRUs and antenna elements in DL/UL/SBFD slots/symbols are illustrated as below. Other methods are not precluded and can be reported by companies.
  + Method 3-1:
    - In DL slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Tx chains.
    - In UL slots, L⁄2 antenna elements on panel group#2 are connected to K⁄2 Rx chains.
    - In SBFD slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Tx chains, and L⁄2 antenna elements on panel group#2 are connected to K⁄2 Rx chains.



* + Method 3-2:
    - In DL slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Tx chains in TxRU group#1.
    - In UL slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Rx chains in TxRU group#1.
    - In SBFD slots, L⁄2 antenna elements on panel group#1 are connected to K⁄2 Tx chains in TxRU group#1, and L⁄2 antenna elements on panel group#2 are connected to K⁄2 Rx chains in TxRU group#1.



Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Sony | Method 3, for non-SBFD slot, it has half the number of Tx & Rx chain compared to legacy TDD, which doesn’t seems like a fair comparison. Why do we need to introduce Method 3 (or Option 3)? |
| Intel | We have similar comments as Sone, and we also are not very clear why method 3 must be introduced. It seems indeed an unfair method given that this would lead to half the TxRU for SBFD compared to legacy TDD. Perhaps, more explanation may be required. |
| Spreadtrum | Agree with Sony and Intel. |
| Ericsson | We can support the proposal in principle. It is worthy to note that for a BS with medium range or wide area power levels where self-interference cancellation or hardware component upgrades are needed, the RX chains needed for SBFD operation are more complicated than for a static TDD network, as it requires more or better hardware, higher energy consumption and higher heat dissipation. Therefore, introducing the constraint that the number of TxRUs should be the same for static TDD and SBFD will lead to an apples-to-orange comparison of performance in which the systems being compared have different complexity. We think that it should be allowed to compare performance based on similar complexity levels, which implies that the number of TxRUs (and antenna elements) could be different between the two systems to equalize the complexity. |
| New H3C | We are fine with the proposal |

#### ***Initial proposal 2-6-3:***

For evaluation of SBFD and dynamic/flexible TDD, use BS antenna radiation pattern as following:

* InH: reuse Table 10 in Report ITU-R M.2412 for both FR1&FR2-1 (same as Wall-mount model in Table A.2.1-7 in TR 38.802)
* Urban Macro/ Dense Urban Macro layer / Dense Urban Micro layer: reuse Table 9 in Report ITU-R M.2412 for both FR1&FR2-1 (same as 3-sector BS antenna radiation model in Table A.2.1-6 in TR 38.802)

Indoor BS antenna radiation pattern (Table 10 in Report ITU-R M.2412)

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Antenna element vertical radiation pattern (dB) |  |
| Antenna element horizontal radiation pattern (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element GE,max | 5dBi |

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| Antenna element vertical radiation pattern (dB) |  |
| Antenna element horizontal radiation pattern (dB) |  |
| Combining method for 3D antenna element pattern (dB) |  |
| Maximum directional gain of an antenna element *GE,max* | 8dBi |

3-TRxP BS antenna radiation pattern (Table 9 in Report ITU-R M.2412)

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
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#### ***Initial proposal 2-6-4:***

For evaluation of SBFD and dynamic/flexible TDD, use UE antenna radiation pattern as following:

* FR1: Omni-directional with 0 dBi element gain
* FR2: reuse Table 11 in Report ITU-R M.2412 (same as UE antenna radiation pattern model 1 in Table A.2.1-8 in TR 38.802)

UE antenna radiation pattern model (Table 11 in Report ITU-R M.2412)

|  |  |
| --- | --- |
| **Parameter** | **Values** |
| **Antenna element radiation pattern in**  **dim (dB)** |  |
| **Antenna element radiation pattern in**  **dim (dB)** |  |
| **Combining method for 3D antenna element pattern (dB)** |  |
| **Maximum directional gain of an antenna element *GE,max*** | 5dBi |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
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|  |  |
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#### ***Initial proposal 2-6-5:***

For evaluation of SBFD operation, companies report the BS antenna configurations used in their simulations. The BS antenna configurations in the following table can be considered for calibration purpose.

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenarios** | **FR** | **Legacy TDD** | **SBFD** |
| **BS antenna configuration for Indoor office** | FR1 | = (4,4,2,1,1; 4,4)  = (0.5, 0.5)λ, +45°/-45° polarization | * SBFD antenna configuration option-3 (Method 3-1)   + Two panel groups   + For each panel group: = (2,4,2,1,1).   + Number of TxRUs: half of legacy TDD   + = (0.5, 0.5)λ, +45°/-45° polarization, (da,H,da,V) = (0, 4)λ |
| FR2-1 | =(4,8,2,1,1; 4,4)  = (0.5, 0.5)λ, +45°/-45° polarization | * SBFD antenna configuration option-3 (Method 3-1)   + Two panel groups   + For each panel group: = (2,8,2,1,1).   + Number of TxRUs: half of legacy TDD   + = (0.5, 0.5)λ, +45°/-45° polarization, (da,H,da,V) = (0, 30)λ |
| **BS antenna configuration for Urban Macro/ Dense Urban Macro layer/ Dense Urban Micro layer** | FR1 | =  (8,8,2,1,1;2,8)  = (0.5, 0.8)λ, +45°/-45° polarization | * SBFD antenna configuration option-3 (Method 3-1)   + Two panel groups   + For each panel group: = (4,8,2,1,1).   + Number of TxRUs: half of legacy TDD   + = (0.5, 0.8)λ, +45°/-45° polarization, (da,H,da,V) = (0, 4)λ |
| FR2-1 | =  (4,8,2,2,2; 1,1)  = (0.5, 0.5)λ, +45°/-45° polarization | * SBFD antenna configuration option-3   + Two panel groups   + For each panel group: = (4,8,2,1,2).   + Number of TxRUs: half of legacy TDD   + = (0.5, 0.5)λ, +45°/-45° polarization, (da,H,da,V) = (0, 30)λ |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |
|  |  |
|  |  |

#### ***Initial proposal 2-6-6:***

For evaluation of SBFD and dynamic/flexible TDD, companies report the UE antenna configurations used in their simulations. The UE antenna configurations in the following can be considered for calibration purpose.

* FR1:
  + 2Tx/Rx: (M,N,P,Mg,Ng;Mp,Np) = (1,1,2,1,1;1,1), (dH,dV) = (N/A, N/A)λ, 0°/90° polarization
* FR2-1:
  + 4Tx/Rx: (M,N,P,Mg,Ng;Mp,Np) = (2,4,2,1,2;1,1); (dH,dV) = (0.5,0.5)λ,(dg,V,dg,H) = (0, 0)λ, 0°/90° polarization

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
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## Issue#2-7: Channel model and penetration loss

### Submitted proposal

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1****: For SBFD deployment case 1, evaluation assumptions in Table 15 and Table 16 in Annex B can be considered as starting point.*  **gNB-UE channel modelling**  ***Proposal 25****: For gNB-UE O2I building penetration loss for Urban macro, Dense urban and HetNet, 80% low-loss model and 20% high-loss model are considered.*  **gNB-gNB channel modelling**  For gNB-gNB channel model, regarding the LOS probability,   * For Macro-to-Macro, if the 2D distance between Macros is not larger than ISD, the LOS probability is set to [0.7]; * For other cases, follow TR 38.901.   Other details can be found in Table 12.  **UE-UE channel modelling**  For UE-UE channel model, reuse TR 38.802 as much as possible, and the details can be found in Table 12..  ***Proposal 26****: For Penetration loss for UE-to-UE link, Table 10 and Table 11 are considered for FR1 and FR 2-1, respectively.*  For UE-UE O2I building penetration loss, penetration loss between UEs in Table A.2.1-13 and Table A.2.1-12 in TR38.802 can be considered as starting point for FR1 and FR2-1, respectively. For HetNet with Macro and InH, minor modifications are needed regarding how to determine Indoor UEs are in the same or different building.  ***Proposal 27****: For evaluation of SBFD operation, channel model in Table 12 can be used as starting point.* |
| Huawei | **gNB-UE channel modelling**  ***Proposal 18:*** *Adopt the gNB-UE channel models listed in Table A.2-1 for evaluation and the following penetration loss model are used:*   * *Indoor office: penetration loss is not modeled.* * *Other cases:*   + *80% low-loss model;*   + *20% high-loss model.*   **gNB-gNB channel modelling**  ***Proposal 19:*** *Adopt the gNB-gNB channel models listed in Table A.2-2 for evaluation on Rel-18 NR duplex operation. And the following modifications are considered:*   * *The ASA and ZSA statistic should be updated to be the same as ASD and ZSD if these two gNBs have a same type. ZoD offset is set to 0.* * *The LOS probability should be updated if these two gNBs have a same type.*   + *The LOS probability of gNB-gNB link is set to 0.8.*   **UE-UE channel modelling**  ***Proposal 20:*** *Adopt the UE-UE channel models listed in Table A.2-3 for evaluation on Rel-18 NR duplex operation. And the following modifications are considered:*   * *Replacing the gNB’ antenna height with UE’s antenna height.* * *The ASD and ZSD statistic should be updated to be the same as ASA and ZSA.* * *Extending the applicability range of the pathloss model for UMi-Street canyon.*   + *The range of pathloss model can be extended from to .* * *The penetration loss model given in TR38.802 can be reused with the following modification.*   + *Indoor office: penetration loss is not modeled.*   + *Other cases:*     - *FR1: reuse the penetration loss model given in Table A.2.1-13 in TR 38.802.*     - *FR2: reuse the penetration loss model given in Table A.2.1-12 in TR 38.802.*     - *Note: for HetNet scenario, whether indoor UEs are in the same or different building is not related to the inter-UE 2D distance, but related to the building topology.* |
| ZTE | ***Proposal 16****:*  *Regarding the gNB-gNB channel model,*   * *LOS probability for gNB-gNB channel are updated as 80%.* * *ASA and ZSA statistics are updated to be the same as ASD and ZSD, ZoD offset = 0.*   *Regarding the UE-UE channel model,*   * *ASD and ZSD statistics are updated to be the same as ASA and ZSA.* |
| Samsung | ***Proposal 7****: For* *LOS probability for gNB-to-gNB channel, down select one option from the following options,*   * *Option 1. Reuse the gNB-to-UE LOS probability equation in TS38.901*    + *Consider gNB as outdoor UE in gNB-gNB channel model* * *Option 2. Modify the gNB-to-UE LOS probability equation to provide higher LOS probability*   + - *Instead of d2D-out, smaller (e.g., half of d2D-out) is used* * *Option 3. Fixed LOS probability*   + *Whether to apply the fixed LOS probability to all gNB-to-gNB channel or nearest gNB-to-gNB channel* |
| Qualcomm | ***Observation 14:*** LOS probability will have large impact on the inter-gNB CLI and any candidate solutions.  ***Proposal 23:*** Consider the current LOS probability equation as the baseline.   * Optional: higher LOS probability (e.g. changed some coefficient or use fixed value for nearby gNBs)   ***Observation 17***: Inter-UE pathloss computation based on leveraging gNB-UE model in 38.901 is not accurate.   * The pathloss equations in 38.901 are based on certain applicability range of base station height which not suitable for UE. * The UMa/UMi PL models consider a minimum distance between gNB and UE as 35/10m which is not valid as inter-UE distance could be small as <1m.   ***Proposal 25***: The UE-to-UE channel can be modelled by leveraging the UE-UE channel model for flexible duplex evaluation in TR in 38.802. |
| vivo | ***Proposal 5***: For NR duplex evolution, the LOS probability formula of gNB-to-UE for gNB-to-gNB and UE-to-UE channel model can be reused at least for InH scenario.  According to the results, we can observe that there is no significant performance difference between reusing LOS probability formula of gNB-to-UE and setting all gNB-to-gNB link to LOS propagation in the InH scenario. |
| CATT | ***Proposal 5***: Reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802 for both FR1 and FR2-1 SBFD evaluation.  ***Proposal 6***: Reuse LOS probability in TR 38.901 and TR 38.802 for gNB-gNB and UE-UE channel model respectively. |
| Nokia, Nokia Shanghai Bell | ***Proposal 9:*** For gNB-gNB channel model, reuse the LOS probability in TR 38.901.  ***Observation 4:*** Reusing TR 38.901 UMi or InH models for UE-UE pathloss calculations may require further adjustments to the line-of-sight (LOS) probability calculations as these only depend on 2D distance but not the Tx-Rx height.  ***Proposal 10:*** For the UE-to-UE channel model for dynamic/flexible TDD and SBFD evaluations, adopt ‘Option 2’ from R1-2205540 RAN1#109-e discussions, i.e. reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802 for both FR1 and FR2 with necessary modifications. |
| Spreadtrum, BUPT | ***Proposal 10:*** Large scale fading should be modelled but small scale fading should not be taken into consider for gNB-gNB channel model and UE-UE channel model in SLS calibration. |
| Intel | ***Proposal 5:*** 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.   ***Proposal 6:*** The existing LOS probability models provided in 38.901 can be reused for the LOS probability model for both gNB-to-gNB and UE-to-UE links.   * To distinguish outdoor to indoor and indoor to indoor cases, similarly as in Rel.14 evaluation for flexible duplexing (FD) InH model is used to model the penetration loss for indoor to indoor case, while UMi is used to model the outdoor to indoor case. |
| Sharp | ***Proposal 5:*** For indoor hotspot, reuse LoS probability formula for gNB-UE links for gNB-gNB/UE-UE links.  ***Proposal 6:*** For Urban Macro, 100% LoS probability can be assumed for gNB-gNB links.  ***Proposal 7:*** For Urban Macro, LoS probability formula for gNB-UE links can be assumed for UE-UE links. |
|  |  |

### Summary

In RAN1#109-e meeting, the following agreements were achieved on gNB-gNB co-channel/adjacent-channel channel model.

|  |
| --- |
| Agreement  For gNB-gNB co-channel/adjacent-channel channel model and UE-UE co-channel/adjacent-channel channel model in RAN1 SLS,   * Large scale fading (e.g., path loss, penetration loss, shadowing) should be modelled, and companies report whether small scale fading (e.g., fast fading including antenna gain) is also modelled in their simulation. * 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 modelled. * FFS: how to model realistic LOS probability for gNB-gNB and UE-UE channel model. * FFS: How to set aligned channel model amongst companies for SLS calibration (if needed).   Agreement  For gNB-gNB channel model, reuse gNB-to-UE channel model in TR 38.901 with necessary modification   * Replacing the UE’s antenna height with gNB’s antenna height, updating the angular spread * FFS: whether/how to update LOS probability. * FFS: Other details and necessary modifications |

**gNB-gNB channel model**

Regarding the LOS probability for gNB-gNB channel model,

* Some companies [CATT, Nokia, Intel] suggest to reuse the gNB-to-UE LOS probability equation in TR 38.901 for gNB-to-gNB channel for all cases.
* Some companies [vivo, Sharp, CMCC] suggest to reuse the gNB-to-UE LOS probability equation in TR 38.901 for InH scenario.
* Some companies [Huawei, ZTE, Qualcomm, vivo, CMCC] consider modified LOS probability for Macro-gNB-to-Macro-gNB channel.
  + [Qualcomm] Optional higher LOS probability for nearby gNBs
  + [CMCC] Higher LOS probability for nearby Macros, i.e., if the2D distance between Macros <= ISD
  + [Huawei] Higher LOS probability if these two gNBs have a same type
  + [Sharp, Ericsson] Higher LOS probability for Urban Macro
* Regarding how to update the LOS probability for gNB-to-gNB channel, the following options are proposed [Samsung, Qualcomm, Huawei, ZTE, CMCC]
  + Option 1. Use fixed LOS probability value, e.g.,
    - 0.7 [CMCC]
    - 0.8 [Huawei, ZTE]
    - 1.0 [Sharp, Ericsson]
  + Option 2. Changed some coefficient in the gNB-to-UE LOS probability equation, e.g.,
    - Instead of d2D-out, smaller (e.g., half of d2D-out) is used [Samsung]

Regarding other details and necessary modifications for gNB-gNB channel model,

* ASA and ZSA statistics are updated to be the same as ASD and ZSD [Huawei, CMCC]
* Set ZoD offset = 0 [Huawei, ZTE]
  + CMCC proposes to set ZoD offset = 0 only for Macro-to-Macro and Micro-to-Micro

Moderator suggests **Initial proposal 2-7-1 and 2-7-2.**

**UE-UE channel model**

In RAN1#109-e meeting, there was a discussion on UE-UE channel model, but no agreement was achieved.

|  |
| --- |
| Updated proposal 4-4-3b  For UE-UE channel model, select option 1:   * 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. |

In RAN#110, some companies expressed their preferences as below. Companies who support Option 2 think if we go with option 1, more modifications need to be discussed.

* For Option 1: Intel, Huawei
* For Option 2: Qualcomm, CATT, Nokia, LG, CMCC

Two companies [Huawei, CMCC] propose to reuse the penetration loss between UEs in Table A.2.1-13 and Table A.2.1-12 in TR38.802, with minor modifications for HetNet scenario, since in such scenario, whether indoor UEs are in the same or different building is not related to the inter-UE 2D distance, but related to the building topology.

Moderator suggests **Initial proposal 2-7-3.**

**gNB-UE channel model**

Two companies [Huawei, CMCC] propose to consider the following gNB-UE O2I building penetration loss

* Indoor office: penetration loss is not modeled.
* Other cases:
  + 80% low-loss model;
  + 20% high-loss model.

Moderator suggests **Initial proposal 2-7-4.**

### 1st Round Proposals

#### ***Initial proposal 2-7-1:***

For LOS probability of gNB-gNB channel,

* For Macro-gNB-to-Macro-gNB case, Option 3 is used
  + Option 1: Reuse the gNB-to-UE LOS probability equation in TS38.901
  + Option 2: Modify the gNB-to-UE LOS probability equation to provide higher LOS probability
    - Instead of d2D-out, smaller (e.g., half of d2D-out) is used
  + Option 3: If the 2D distance between two Macro gNBs are less than or equal to the ISD (200m for Dense Urban, and 500m for Urban Macro), set the LOS probability to X; Otherwise, reuse gNB-to-UE LOS probability equation in TR 38.901.
    - FFS: X = [0.7, 0.8, 1]
* For other cases, reuse gNB-to-UE LOS probability equation in TR 38.901.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | Option 1 is preferred, and we do not think we may need to over-complicate the model. |
| Spreadtrum | Prefer Option 3. |
| Ericsson | We support the proposal and think that Option 3 is a good compromise. However, Option 2 with a scaling factor of about 10 can also work. Option 1 provides very low LOS probability at 500m, and this is not realistic in our opinion. |
| New H3C | We are fine with the proposal |

#### ***Initial proposal 2-7-2:***

Adopt the following table for gNB-gNB channel model and gNB-UE channel model.

gNB-UE channel model and gNB-gNB channel model

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Dense urban, Urban macro** | **Indoor office** | **HetNet with Urban Macro and Indoor office** |
| Large-scale channel parameters | FR1:   * Macro-to-UE: UMa in TR 38.901 * Micro-to-UE: UMi-Street canyon in TR 38.901 * Macro-to-Macro: UMa in TR 38.901 (hUE =25m), * Macro-to-Micro: UMa in TR 38.901 (hUE =10m) * Micro-to-Micro: UMi-Street canyon in TR 38.901 (hUE =10m)   FR2-1:   * Macro-to-UE: UMa in TR 38.901 * Micro-to-UE: UMi-Street canyon in TR 38.901 * Macro-to-Macro: UMa in TR 38.901 (hUE =25m) * Macro-to-Micro: UMa in TR 38.901 (hUE =10m) * Micro-to-Micro: UMi-Street canyon in TR 38.901 (hUE =10m) | FR1:   * TRP-to-UE: InH-Office in TR 38.901 * TRP-to-TRP: InH-Office in TR 38.901 (hUE =3m)   FR2-1:   * TRP-to-UE: InH-Office in TR 38.901 * TRP-to-TRP: InH-Office in TR 38.901 (hUE =3m) | FR1:   * Macro-to-UE: UMa in TR 38.901 * Indoor-TRP-to-UE: InH-Office in TR 38.901 * Macro-to-Macro: UMa in TR 38.901 (hUE =25m) * Macro-to-Indoor-TRP: UMa in TR 38.901 (hUE =3m) * Indoor-TRP-to-Indoor-TRP: InH-Office in TR 38.901 (hUE =3m)   FR2-1:   * Macro-to-UE: UMa in TR 38.901 * Indoor TRxP -to-UE: InH-Office in TR 38.901 * Macro-to-Macro: UMa in TR 38.901 (hUE =25m) * Macro-to-Indoor-TRP: UMa in TR 38.901 (hUE =3m) * Indoor-TRP-to-Indoor-TRP: InH-Office in TR 38.901 (hUE =3m) |
| Fast fading parameters | FR1:   * Macro-to-UE: UMa in TR 38.901 * Micro-to-UE: UMi-Street canyon in TR 38.901 * Macro-to-Macro: UMa O2O in TR 38.901 (hUE =25m); ASA and ZSA statistics updated to be the same as ASD and ZSD; ZoD offset = 0 * Macro-to-Micro: UMa O2O in TR 38.901 * Micro-to-Micro: UMi-Street canyon O2O in TR 38.901 (hUE=10m); ASA and ZSA statistics updated to be the same as ASD and ZSD; ZoD offset = 0   FR2-1:   * Macro-to-UE: UMa in TR 38.901 * Micro-to-UE: UMi-Street canyon in TR 38.901 * Macro-to-Macro: UMa O2O in TR 38.901 (hUE=25m); ASA and ZSA statistics updated to be the same as ASD and ZSD; ZoD offset = 0 * Macro-to-Micro: UMa O2O in TR 38.901 * Micro-to-Micro: UMi-Street canyon O2O in TR 38.901 (hUE=10m); ASA and ZSA statistics updated to be the same as ASD and ZSD; ZoD offset = 0 | FR1:   * TRP-to-UE: InH-Office in TR 38.901 * TRP-to-TRP: InH-Office in TR 38.901 (hUE=3m), ASA and ZSA statistics updated to be the same as ASD and ZSD   FR2-1:   * TRP-to-UE: InH-Office in TR 38.901 * TRP-to-TRP: InH-Office in TR 38.901 (hUE =3m), ASA and ZSA statistics updated to be the same as ASD and ZSD | FR1:   * Macro-to-UE: UMa in TR 38.901 * Indoor-TRP-to-UE: InH-Office in TR 38.901 * Macro-to-Macro: UMa O2O in TR 38.901 (hUE =25m); ASA and ZSA statistics updated to be the same as ASD and ZSD; ZoD offset = 0 * Macro-to-Indoor-TRP: UMa O2O in TR 38.901 * Indoor-TRP-to-Indoor-TRP: InH-Office in TR 38.901 (hUE=3m), ASA and ZSA statistics updated to be the same as ASD and ZSD   FR2-1:   * Macro-to-UE: UMa in TR 38.901 * Indoor-TRP-to-UE: InH-Office in TR 38.901 * Macro-to-Macro: UMa O2O in TR 38.901 (hUE=25m); ASA and ZSA statistics updated to be the same as ASD and ZSD; ZoD offset = 0 * Macro-to-Indoor-TRP: UMa O2O in TR 38.901 * Indoor-TRxP-to-Indoor-TRP: InH-Office in TR 38.901 (hUE =3m), ASA and ZSA statistics updated to be the same as ASD and ZSD |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | For Hetnet gNB-UE channel, only Macro-to-UE and Indoor-TRP-to-UE are taken into account. Does it mean, UE in Indoor can only select indoor as serving cell and UE outside indoor can only select Macro as serving cell? |
| Ericsson | We have same questions regarding HetNets scenario as discussed in our previous comments. Furthermore, Macro -to-Micro and Macro-to-Indoor will also have a reverse link which needs to be modelled. |
| New H3C | We are fine with the proposal |

#### ***Initial proposal 2-7-3:***

For UE-UE channel model, reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802 for both FR1 and FR2, and adopt the following tables.

UE-UE channel model

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Dense urban, Urban macro** | **Indoor hotspot** | **HetNet with Urban Macro and Indoor office** |
| Large-scale channel parameters | FR1:   * UE-to-UE: A.2.1.2 in TR36.843(\*), penetration loss between UEs follows Table X   FR2-1:   * UE-to-UE: UMi-Street canyon in TR 38.901 (hBS =1.5m ~ 22.5m), penetration loss between UEs follows Table Y | FR1:   * UE-to-UE: A.2.1.2 in TR36.843 (\*)   FR2-1:   * UE-to-UE: InH-Office in TR 38.901 (hBS =1.5m) | FR1:   * UE-to-UE: A.2.1.2 in TR36.843(\*), penetration loss between UEs follows Table X   FR2-1:   * UE-to-UE: UMi-Street canyon in TR 38.901 (hBS =1.5m), penetration loss between UEs follows Table Y |
| Fast fading parameters | FR1:   * UE-to-UE: A.2.1.2 in TR36.843 (ITU InH) for indoor to indoor, and 3D UMi for other cases. ASD and ZSD statistics updated to be the same as ASA and ZSA.   FR2-1:   * UE-to-UE: UMi-Street canyon in TR 38.901; ASD and ZSD statistics updated to be the same as ASA and ZSA. | FR1:   * UE-to-UE: A.2.1.2 in TR36.843 (ITU InH), ASD statistics updated to be the same as ASA.   FR2-1:   * UE-to-UE: InH-Office in TR 38.901 (hBS =1.5m), ASD and ZSD statistics updated to be the same as ASA and ZSA | FR1:   * UE-to-UE: A.2.1.2 in TR36.843 (ITU InH) for indoor to indoor, and 3D UMi for other cases. ASD and ZSD statistics updated to be the same as ASA and ZSA.   FR2-1:   * UE-to-UE: UMi-Street canyon in TR 38.901 ; ASD and ZSD statistics updated to be the same as ASA and ZSA. |
| (\*): For outdoor to indoor case, and indoor to indoor case, use “Remaining Layout Options” in A.2.1.2 of TR36.843 for pathloss calculation, and “ITU-R IMT UMi” for LOS Probability derivation. For outdoor to indoor case, the penetration loss term “20.0+0.5\* din” is excluded in pathloss formula given in A.2.1.2 of TR36.843, and the penetration loss is derived according to Table X. | | | |

Table X: Penetration loss for UE-to-UE link for FR1 (follow Table A.2.1-13 in TR38.802 with difference highlighted in red)

|  |  |  |  |
| --- | --- | --- | --- |
| Location of UE\_x | Location of UE\_y | Sub-scenario | Penetration loss (for around 4GHz and 2GHz) |
| Indoor | Indoor | In different building (if inter-user 2D distance > 50m for Urban macro and Dense urban scenario; or if two UEs within different buildings for HetNet with Macro and InH) | where PLtw=20dB, and  in meter TR 36.814 is the distance from user to internal wall, *i*=*x*, *y,* and *U(a,b)* indicates uniform distribution. |
| In the same building (if inter-user 2D distance ≤ 50m for Urban macro and Dense urban scenario; or if two UEs within the same building for HetNet with Macro and InH) | for UEs on different floors TR 36.872; otherwise 0dB. |
| Indoor | Outdoor | N.A. | with PLtw=20dB and  in meter is the building penetration loss as given by TR 36.814.  is the car penetration loss as given by subclause 7.4.3 in TR 38.901 [15]. |
| Outdoor | Indoor | N.A. | is the car penetration loss as given by subclause 7.4.3 in TR 38.901 [15].  with PLtw=20dB and  in meter is the building penetration loss as given by TR 36.814. |
| Outdoor | Outdoor | N.A. | is the car penetration loss as given by subclause 7.4.3 in TR 38.901 [15].  *i*=*x*, *y* |

Table Y: Penetration loss for UE-to-UE link for FR2-1 (follow Table A.2.1-12 in TR38.802 with difference highlighted in red)

|  |  |  |  |
| --- | --- | --- | --- |
| Location of UE\_x | Location of UE\_y | Sub-scenario | Penetration loss (for around 30GHz) |
| Indoor | Indoor | In different building (if inter-user 2D distance > 50m for Urban macro and Dense urban scenario; or if two UEs within different buildings for HetNet with Macro and InH) | is the building penetration loss as given by subclause 7.4.3 in TR 38.901 [15].  *i*=*x*, *y* |
| In the same building (if inter-user 2D distance ≤ 50m for Urban macro and Dense urban scenario; or if two UEs within the same building for HetNet with Macro and InH) | where *L*concrete is given by Table 7.4.3-1 in TR 38.901 [15], and *ni* is the floor number for UE\_i, *i*=*x*, *y*. |
| Indoor | Outdoor | N.A. | is the building penetration loss as given by subclause 7.4.3 in TR 38.901 [15].  is the car penetration loss as given by subclause 7.4.3 in TR 38.901 [15]. |
| Outdoor | Indoor | N.A. | is the car penetration loss as given by subclause 7.4.3 in TR 38.901 [15].  is the building penetration loss as given by subclause 7.4.3 in TR 38.901 [15]. |
| Outdoor | Outdoor | N.A. | is the car penetration loss as given by subclause 7.4.3 in TR 38.901 [15].  *i*=*x*, *y* |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Ericsson | It is not clear to us why UMi is ok for FR2-1 but not FR1? |
|  |  |
|  |  |

#### ***Initial proposal 2-7-4:***

Adopt the following gNB-UE O2I building penetration loss model:

* Indoor office: penetration loss is not modeled.
* Percentage of high loss and low loss building type for Urban Macro / Dense Urban [refer to table 5B of ITU M.2412]:
  + 80% low-loss model
  + 20% high-loss model
  + Note: The building type is determined by comparing the random variable with P1, where P1 is the probability of the building type with low loss penetration. If the realization of the random variable is less than P1, the building type is low loss; otherwise the building type is high loss [refer to section 5.3.3 of ITU M.2412].
* FFS: HetNet with Urban Macro and Indoor office

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | Fine with this proposal. |
| Ericsson | We are ok with the proposal. |
| New H3C | We are fine with the proposal |

## Issue#2-8: Others

### Submitted proposal

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | ***Proposal 1****: For SBFD deployment case 1, evaluation assumptions in Table 15 and Table 16 in Annex B can be considered as starting point.*  ***Proposal 28****: BS transmit powers for legacy TDD in Table 13 is used for system level simulation.*  Table 13 BS transmit power for legacy TDD.   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | **Dense urban** | **Urban macro** | **Indoor hotspot** | **HetNet with Urban Macro and Indoor office** | | **FR1** | **Macro Layer:**  [44] dBm for 100MHz [TR 38.802 Table A.2.1-1]  **Micro Layer:**  [40] dBm for 100MHz [TR 38.802 Table A.2.1-1, 33dBm for 20MHz system bandwidth] | [53] dBm for 100MHz | 24 dBm for 100MHz [TR 38.802 Table A.2.1-1] [TR 38.828 Table 5.2.1.1.2-1] | **Macro Layer:**  [44] dBm for 100MHz [TR 38.802 Table A.2.1-1]  **Indoor TRxP:**  24 dBm for 100MHz [TR 38.802 Table A.2.1-1] [TR 38.828 Table 5.2.1.1.2-1] | | **FR2-1** | **Macro Layer:**  40 dBm for 200MHz. EIRP should not exceed 73 dBm. [TR 38.802 Table A.2.1-1]  **Micro Layer:**  33 dBm for 200MHz. EIRP should not exceed 68 dBm. [TR 38.802 Table A.2.1-1] [TR 38.828 Table 5.2.2.4-1] | **N.A.** | 23 dBm for 200MHz. EIRP should not exceed 58 dBm. [TR 38.802 Table A.2.1-1] [TR 38.828 Table 5.2.2.4-1] | **N.A.** |   ***Proposal 29****: For comparison between legacy TDD and SBFD, the following alternatives can be considered.*   * *Alt 1: Keep the same BS transmit power spectrum density for SBFD and legacy TDD. BS transmit power is proportional to the RBs used for DL transmission*   + *At least used for calibration purpose* * *Alt 2: The BS transmit power spectrum density in SBFD symbols can be boosted compared to that in DL-only symbols or for legacy TDD.*    + *Companies to report the power boosting assumptions*   ***Proposal 32****: For evaluation methodologies for dynamic/flexible TDD, resue SBFD as much as possible, e.g.,*   * *BS transmit power: Table 13 is considered.*   ***Proposal 33:*** *For dynamic/flexible TDD, evaluation assumptions in Table 17 and Table 18 in Annex C can be considered as starting point.*  ***Proposal 19****:* *In SLS for performance evaluation of legacy TDD and SBFD, DL and UL traffic should be simulated simultaneously, and each UE has both UL and DL traffic.* |
| Huawei | ***Proposal 24:*** *Adopt the UL and DL power control parameters listed in Table A.5 for evaluation on Rel-18 NR duplex operation.*   * *Adopt the power boosting for gNB DL transmission in SBFD slot.* |
| ZTE | For system evaluation, the DL and UL need to be simulated simultaneously in the same system in order to evaluate the DL/UL interference and comprehensively understand the potential gain and impact to both DL and UL.  **Calibration**  ***Proposal 6****: 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.*   * *The ACLR model can be reused as the simplified interference model for calibration by assuming the adjacent channel interference and inter-subband interference is flat over frequency domain* |
| 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 18:*** 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 10***: Support SLS as main tool for the evaluation of subband full duplex study.   * LLS could be additional used for the study of inter-UE CLI. * Link-budget analysis could be additionally used for the evaluation of coverage gain in SBFD.   ***Proposal 27***: RAN 1 shall consider simulation parameters in Tables 7, and 8 for FR1 full duplex evaluation.  ***Proposal 28***: RAN 1 shall consider simulation parameters in Tables 7, 9, and 10 for FR2 full duplex evaluation.  ***Proposal 32:*** Support SLS as main tool for the evaluation of potential enhancement of dynamic/flexible TDD study.  ***Proposal 35***: RAN 1 shall consider simulation parameters Table 14 FR1 evaluation on Dynamic/flexible TDD  ***Proposal 36***: ¬RAN 1 shall consider simulation parameters in Tables 7, 9, and 15 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. |
| DOCOMO | ***Proposal 2:*** Simulation assumptions defined in Tables 5.2.1.1.1-1, 5.2.1.1.2-1, 5.2.1.1.3-1, and 5.2.1.4-1 in TR 38.828 are the baseline for the simulation assumptions for SBFD evaluation.  ***Proposal 3:*** Subcarrier spacing, UE antenna number/configuration, BS/UE TxRU configuration, modulation of DL/UL, and UE speed should be defined for the 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 NR duplex evolution, system-level simulation assumptions and parameters in Table B-1 in Annex can be considered. |
| OPPO | ***Proposal 1***: It needs to be discussed whether downlink scheduling could use the resource in uplink subband. |
| CATT | ***Proposal 10***: Adopt simulation assumptions in Table 1 and Table 2 for SBFD system evaluation.  ***Proposal 11:*** Performance of dynamic/flexible TDD with existing CLI handling schemes is the baseline for comparison with new CLI handling schemes.  ***Proposal 12:*** Adopt simulation assumptions in Table 3 for dynamic/flexible TDD system evaluation. |
| Nokia, Nokia Shanghai Bell | ***Proposal 13:*** For SBFD and dynamic/flexible TDD evaluations, RAN1 to agree on simulation bandwidth, gNB/UE transmit power and antenna gain, antenna panel model, among other assumptions.  • See Table 1 and Table 2 of this contribution for proposed simulation assumptions for FR1 UMa and InH for SBFD Deployment Case 1. |
| Spreadtrum, BUPT | ***Proposal 2:*** Simulation assumption for indoor office listed in Appendix 8.1 should be adopted.  ***Proposal 3:*** Simulation assumption for urban macro listed in Appendix 8.2 should be adopted.  ***Proposal 6:*** In dynamic/flexible TDD, Hetnet scenario calibration is needed. |
| Intel | ***Proposal 8:*** To ensure comparable results are generated, SLS calibration among companies is preferred   * Companies may provide at least geometry results using agreed channel models and LOS models * Results for FR1 in indoor deployment could be mandatory, but companies can provide optionally results for any other deployments |
| NEC | ***Observation 1*** Currently following options can be considered for SBFD within a TDD carrier:  a. Single BWP containing either UL or DL sub-band (but not both). UL and DL sub-bands are present in different BWPs for enabling SBFD  b. Single BWP containing both UL and DL sub-band(s) |
| Charter Communications | ***Proposal 2:*** Study the CLI effect in N77 band especially the effect of adjacent bands with SBFD and dynamic TDD to decide the placement of full duplex sub-band networks at the band edge.  ***Proposal 3:*** Study the blocking interference in the full duplex sub-band networks and decide the placement of full duplex sub-band at band edge. |
|  |  |

### Summary

Regarding other evaluation assumptions, Moderator suggests **Initial proposal 2-8-1.**

Regarding the BS transmit power for legacy TDD, various values are proposed as below. Moderator suggests **Initial proposal 2-8-2.**

|  |  |  |
| --- | --- | --- |
|  | **FR1** | **FR2-1** |
| **Urban macro** | * Option 1: [53] dBm for 100MHz [Huawei, Nokia, ZTE, CMCC] * Option 2: [49] dBm for 100MHz [vivo, CATT, Spreadtrum] [refer to TR 38.828 Table 5.2.1.4-1] * Option 3: [45] dBm for 100MHz [Qualcomm] * Option 4: [50] dBm for 100MHz (same antenna gain), [47] dBm for 100MHz (same antenna area) [Ericsson (per polarization)] * Option 5: [56] dBm for 100MHz [MediaTek] * Option 6: [52] dBm for 100MHz [LG] * Option 7: [51] dBm for 100MHz [NEC] | N.A. |
| **Dense Urban Macro layer** | * Option 1: [53] dBm for 100MHz [Huawei] * Option 2: [49] dBm for 100MHz [vivo] * Option 3: [44] dBm for 100MHz [CMCC] [refer to TR 38.802 Table A.2.1-1] * Option 4: [45] dBm for 100MHz [Qualcomm] * Option 5: [47] dBm for 100MHz [LG] * Option 6: [51] dBm for 100MHz [Xiaomi] | * Option 1: [43] dBm for 200MHz [vivo] [refer to TR 38.828 Table 5.2.2.4-1] * Option 2: [40] dBm for 200MHz. EIRP should not exceed 73 dBm. [CATT, CMCC] [refer to TR 38.802 Table A.2.1-1] |
| **Dense Urban Micro layer** | * Option 1: [49] dBm for 100MHz [vivo] * Option 2: [44] dBm for 100MHz [CATT] * Option 3: [40] dBm for 100MHz [ZTE, CMCC] [refer to TR 38.802 Table A.2.1-1] * Option 4: [45] dBm for 100MHz [Qualcomm] | * Option 1: [43] dBm for 200MHz [vivo, Qualcomm] * Option 2: [33] dBm for 200MHz. EIRP should not exceed 68 dBm. [CMCC] [refer to TR 38.802 Table A.2.1-1 and TR 38.828 Table 5.2.2.4-1] * Option 3: [35] dBm for 200MHz [CATT] * Option 4: [40] dBm per 80 MHz. EIRP should not exceed 73 dBm [Qualcomm] |
| **Indoor hotspot** | * Option 1: [31] dBm for 100MHz [ZTE, Nokia] * Option 2: [24] dBm for 100MHz [Spreadtrum, Apple, CMCC] [refer to TR 38.802 Table A.2.1-1 and TR 38.828 Table 5.2.1.1.2-1] * Option 3: [23] dBm for 100MHz [Qualcomm] | * Option 1: [23] dBm for 200MHz. EIRP should not exceed 58 dBm. [Huawei, vivo, Spreadtrum, CMCC] [refer to TR 38.802 Table A.2.1-1 and TR 38.828 Table 5.2.2.4-1] * Option 2: [24] dBm for 200MHz [CATT] * Option 3: [23] dBm per 80 MHz. EIRP should not exceed 58 dBm [Qualcomm] |

Regarding the BS transmit power forSBFD, two alternatives are proposed.

* Alt 1: Keep the same BS transmit power spectrum density for SBFD and legacy TDD. BS transmit power is proportional to the RBs used for DL transmission
* Alt 2: The BS transmit power spectrum density in SBFD symbols can be boosted compared to that in DL-only symbols or for legacy TDD, e.g., the following is proposed by [Huawei]

Moderator suggests **Initial proposal 2-8-3.**

### 1st Round Proposals

#### ***Initial proposal 2-8-1:***

For evaluation of SBFD and dynamic/flexible TDD, adopt the following evaluation assumptions.

|  |  |  |
| --- | --- | --- |
|  | **FR1** | **FR2-1** |
| System bandwidth | 100MHz | 200MHz |
| Numerology | 14 OFDM symbol slot  SCS = 30kHz | 14 OFDM symbol slot  SCS = 60kHz |
| UE Tx power | 23dBm | 23 dBm. EIRP should not exceed 43 dBm  [refer to TR 38.802 Table A.2.1-1] |
| Open loop power control parameters | Companies to report power control parameters.  For calibration:   * P0= -60 dBm, alpha = 0.6 for InH [refer to TR 37.910, evaluation assumption in B.4.1\_eMBB\_SE.zip] * P0= -86 dBm, alpha = 0.9 for Dense Urban [refer to TR 37.910, evaluation assumption in B.4.1\_eMBB\_SE.zip] * P0= -80 dBm, alpha = 0.8 for Urban Macro | |
| BS receiver noise figure | 5dB  [refer to TR 38.802 Table A.2.1-1] | 7dB  [refer to TR 38.802 Table A.2.1-1] |
| UE receiver noise figure | 9 dB  [refer to TR 38.802 Table A.2.1-1] | 13 dB (baseline), 10 dB (optional)  [refer to TR 38.802 Table A.2.1-1] |
| UE receiver | MMSE-IRC as the baseline receiver.  Note: Advanced receiver is not precluded.  [refer to TR 38.802 Table A.2.1-1] | |
| Feedback assumption | Realistic [refer to TR 38.802 Table A.2.1-1] | |
| Channel estimation | Realistic [refer to TR 38.802 Table A.2.1-1] | |
| UE processing capability | UE processing capability 1 as baseline   * PDSCH decoding time N1 [symbols]: 13 for FR1 (30kHz SCS) * PUSCH preparation time N2 [symbols]: 12 for FR1 (30kHz SCS) | UE processing capability 1 as baseline   * PDSCH decoding time N1 [symbols]: 20 for FR2 (60kHz SCS) * PUSCH preparation time N2 [symbols]: 23 for FR2 (60kHz SCS) |
| Handover margin | 3 dB [refer to TR 38.828 Table 5.2.1.4-1] | |
| UE attachment | Based on RSRP from port 0  [refer to TR 37.910, evaluation assumption in B.4.1\_eMBB\_SE.zip] | Based on RSRP from port 0. The UE panel with the best receive SNR is chosen. i.e. no combining is done between panels.  [refer to TR 37.910, evaluation assumption in B.4.1\_eMBB\_SE.zip] |
| Polarized antenna model | Model-1 in clause 7.3.2 in TR 38.901 | |
| DL/UL Modulation | Up to 256QAM | |
| Transmission scheme | Companies to report transmission schemes (e.g., SU-MIMO, MU-MIMO, maximum layers for SU-MIMO/MU-MIMO, etc)  For calibration, consider SU-MIMO with single layer for both DL and UL | |
| Scheduling | PF | |
| Overhead | Companies to report the overhead assumption | |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | Fine with this proposal. |
| Ericsson | Support the proposal in principle |
| New H3C | We are fine with the proposal |

#### ***Initial proposal 2-8-2:***

For evaluation of SBFD and dynamic/flexible TDD, the following BS transmit power for legacy TDD are considered. Further down-selection is needed.

|  |  |  |
| --- | --- | --- |
|  | **FR1** | **FR2-1** |
| **Urban macro** | * Option 1: [53] dBm for 100MHz * Option 2: [49] dBm for 100MHz [refer to TR 38.828 Table 5.2.1.4-1] * Option 3: [45] dBm for 100MHz | N.A. |
| **Dense Urban Macro layer** | **Option 3 is adopted.**   * Option 1: [53] dBm for 100MHz * Option 2: [49] dBm for 100MHz * Option 3: [44] dBm for 100MHz [refer to TR 38.802 Table A.2.1-1] | **Option 1 is adopted.**   * Option 1: [43] dBm for 200MHz [refer to TR 38.828 Table 5.2.2.4-1] * Option 2: [40] dBm for 200MHz. EIRP should not exceed 73 dBm. [refer to TR 38.802 Table A.2.1-1] |
| **Dense Urban Micro layer** | **Option 3 is adopted.**   * Option 1: [49] dBm for 100MHz * Option 2: [44] dBm for 100MHz * Option 3: [40] dBm for 100MHz [refer to TR 38.802 Table A.2.1-1] | **Option 2 is adopted.**   * Option 1: [43] dBm for 200MHz * Option 2: [33] dBm for 200MHz. EIRP should not exceed 68 dBm. [refer to TR 38.802 Table A.2.1-1 and TR 38.828 Table 5.2.2.4-1] |
| **Indoor hotspot** | **Option 2 is adopted.**   * Option 1: [31] dBm for 100MHz * Option 2: [24] dBm for 100MHz [refer to TR 38.802 Table A.2.1-1 and TR 38.828 Table 5.2.1.1.2-1] * Option 3: [23] dBm for 100MHz | **Option 1 is adopted.**   * Option 1: [23] dBm for 200MHz. EIRP should not exceed 58 dBm. [refer to TR 38.802 Table A.2.1-1 and TR 38.828 Table 5.2.2.4-1] |

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Intel | No strong preference, although it may be preferable to align with the values used in 38.802. |
| Spreadtrum | We are open to those options. But for indoor hotspot, we prefer option 2 with low transmit power. |
| Ericsson | We are open to these options. |
| New H3C | We are open to discus about these options. |

#### ***Initial proposal 2-8-3:***

For comparison between legacy TDD and SBFD, companies should report the assumption of BS transmit power on DL slots and SBFD slots in SBFD operation.

* For calibration purpose, assume the BS transmit power spectrum density is kept the same for SBFD operation and legacy TDD operation. BS transmit power is proportional to the RBs used for DL transmission.

Companies are encouraged to provide comments in the table below.

|  |  |
| --- | --- |
| **Company** | **Comment** |
| Spreadtrum | We prefer toadopt power density spectrum boosting for SBFD to see the impact of CLI. Also, the coupling loss would not be able to align with legacy TDD. |
| Ericsson | We support the proposal in principle to report the BS transmit power on DL slots for SBFD operation. We need further clarification for the calibration purpose. |
| New H3C | We are fine with the proposal |

# Issue#3: LLS Evaluation Methodology and link budget analysis

## Issue#3-1: Coverage performance of SBFD

### Submitted proposal

|  |  |
| --- | --- |
| **Company** | **Proposals** |
| CMCC | *Coverage*  ***Proposal 15****: Take link level evaluation methodology in TR 38.830 (i.e., LLS + Link budget analysis) as starting point to evaluate the coverage performance (e.g., MPL, MCL, MIL) for SBFD.*  ***Proposal 30****: 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, with the following consideration:*   * *Scenario and frequency:*    + *FR1 (4GHz): Urban Macro with ISD = 500m* * *Target channel: PUSCH for eMBB* * *Target data rate: UL 1Mbps* * *Performance metrics: MPL* * *High level evaluation method*   + *Step 1: Perform LLS to obtain SNR for legacy TDD and SBFD with the following considerations*     - *[15] PRB, MCS index= [0], SCS = 30kHz*     - *Legacy TDD: DDDSU, S=[12D:2G:0U]*       * *w/o repetition (PUSCH repetition type A), w/o HARQ*     - *SBFD: DXXXU, XXXXU, XXXXX*       * *w/ repetition (PUSCH repetition type A), w/o HARQ*   + *Step 2: Perform Link budget analysis by reusing the link budget template in TR 38.830 as much as possible to obtain MPL for legacy TDD and SBFD.*   ***Proposal 31****:* *For link level simulation & Link budget analysis for the coverage performance of SBFD, consider the following options:*   * *For gNB self-interference modelling,*    + *Opt 1: SI is modelled as white noise, and the power of residual SI is modelled in a similar way as in SLS. The residual SI can be modelled as an additional white noise in LLS or as an interference margin in the Link budget template.*   + *Opt 2: Generation of the self-interference signals and self-interference cancellation at the gNB are modelled in LLS, e.g., use a model to capture the overall "net" effect of key gNB transmit chain components, i.e., CFR + DPD + PA.* * *For inter-site gNB-gNB co-channel inter-subband CLI modelling,*   + *Opt 1: Inter-site gNB-gNB co-channel inter-subband CLI is modelled as an interference margin in the Link budget template. E.g., the interference margin can be obtained by the average IoT degradation due to Inter-site gNB-gNB co-channel inter-subband CLI in SLS.*   + *Opt 2: Separate gNB-gNB links are modelled in LLS for modelling inter-site gNB-gNB co-channel inter-subband CLI. Receiver algorithms (e.g., MMSE-IRC) can be used to mitigate the inter-site gNB-gNB co-channel inter-subband CLI.* |
| Huawei | ***Proposal 30:*** *The link level simulation is used to evaluate link level algorithm for SBFD and dynamic/ flexible TDD enhancement.*  ***Proposal 31:*** *The link level simulation and link budget are used to evaluate coverage performance for SBFD. The basic evaluation methodology for coverage is based on link level simulation and link budget, and articulated in 2 steps. The evaluation assumptions for step 1 are provided in Table C.1. Link budget template for step 2 for SBFD is provided in Table C.2.*   * *Step 1: Obtain the required SINR for the physical channels under target scenarios and service/ reliability requirements. Simulations have been conducted neglecting:* * *Constraints imposed by certain beamforming implementation, such as the possibility to simultaneously receive or transmit with maximum gain in more than one direction;* * *PTRS overhead and compensation algorithms.* * *Step 2: Obtain the baseline performance based on required SINR and link budget template.*   ***Proposal 32:*** *Adopt the metrics of MCL, MIL, and MPL for evaluation on coverage performance of Rel-18 NR duplex operation. The definition of these metrics are given as follows.*   * *Definition of MCL:*   + *MCL = Total transmit power – Receiver sensitivity + gNB antenna gain (component 2).*   + *More details can be found in the link budget template shown in Annex C.* * *Definition of MIL:*   + *MIL = Total transmit power – Receiver sensitivity – Tx loss – Rx loss + gNB antenna gain (component 2 + 3 + 4) + UE antenna gain.*   + *More details can be found in the link budget template shown in Annex C.* * *Definition of MPL:*   + *MPL = MIL – Shadow fading margin + BS selection/macro-diversity gain – Penetration margin + Other gains.*   + *More details can be found in the link budget template shown in Annex C.* |
| Samsung | ***Proposal 13:*** *For LLS, the following components incurring non-linearity should be taken into account.*   * *PA, DPD, and CFR at gNB side and UE side* * *For PA, the starting point is the PA model shared by RAN4 LS in Rel-14 (R1-166004)* * *FFS how to model DPD and CFR*   ***Proposal 14:*** *RAN1 should discuss how to model the self-interference channel between TX baseband chain and RX baseband chain. At least the following components can be included.*   * *Internal coupling path, which has fixed delay (almost zero-delay) and fixed power* * *Antenna reflection path, which has fixed delay (very small delay, depending on antenna size) and fixed power* * *Clutter reflection path, which has variable small delay and variable power*   ***Proposal 15:*** *For LLS evaluation, consider the following simplified self-interference model.*   * *The self-interference seen at RX baseband chain is modeled as white Gaussian interference with the interference power. Its interference power is decided as in SLS*   ***Proposal 16:*** *For LLS evaluation, reuse the performance metric and evaluation assumption in Rel-17 NR Coverage Enhancement WI.*  ***Proposal 17:*** *For LLS evaluation, the following uplink channels can be evaluated.*   * *PUSCH and PUCCH* * *FFS: PRACH*   ***Proposal 18:*** *For LLS evaluation, consider the following UL transmission schemes.*   * *PUSCH repetition type A and PUSCH repetition type B* * *TB over multiple slots* * *PUCCH repetitions* * *Joint channel estimation* |
| DOCOMO | ***Proposal 6***: MPL is used for the coverage evaluation, and link level simulation is performed to derive MPL. |
| CATT | ***Proposal 9:*** Use the methodology (LLS+link buget analysis) for R17 coverage enhancement for SBFD coverage evaluation. |
| New H3C | ***Proposal 2:*** For metrics considered for SBFD and dynamic/flexible TDD evaluation, the coverage performance metrics (e.g., MPL, MCL, MIL) defined in TR 38.830 for coverage evaluation of SBFD should be reused. |
| Intel | ***Proposal 10:*** In order to investigate the performance gain for coverage realized by SBFD, MPL should be also included in the list of performance metrics.   * As Rel. 17 NR coverage enhancements studies, RAN1 should focus on link-budget analysis to determine MPL, which already includes MCL/MIL as intermediate steps, with use of LLS evaluations to derive the required SNRs and possibly SLS evaluations to estimate Tx antenna gain correction factor (up to companies). * 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 SBFD operation. * Consider Table 1 and Table 2 in the Appendix I for SBFD performance evaluation for FR1 and FR2, respectively. * Discuss further on self-interference modelling for link-level simulations and coverage analysis for SBFD. |
| Ericsson | **SBFD self-interference mitigation**  *gNB Transmitter Modeling*  ***Observation 1:*** It is not necessary to perform link level simulations using separate models for DPD and PA.  ***Proposal 1:***Adopt a net effect model for link-level simulations that captures the essential behaviours of a realistic DPD and PA combination with compliance to the base station ACLR requirements. This requires input from RAN4.  ***Proposal 2:***Adopt a simple crest factor processing model, e.g., hard clipping + bandpass filtering, that captures the essential behaviors of a BS design to increase transmit power. This requires input from RAN4.    *gNB Antenna and Interference Channel*  ***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:***For link level assessment of SBFD, proper modelling of advanced antennas as well as modelling of beamforming impact on the BS TX to RX isolation should be considered.  ***Proposal 6:***For link level assessment of SBFD, proper modelling of advanced antennas as well as modelling of beamforming impact on the inter-sector TX to RX isolation should be considered.  *gNB Receiver Modeling*  ***Proposal 7:***Adopt a third order representation model in RAN1 studies to capture the essential behaviors of typical high-gain low noise amplifiers (LNA) in BS receiver chains.  ***Observation 2:*** The integrated inter-carrier interference (ICI) power across the 100 MHz carrier bandwidth is around -50 dBc, which is at similar level as typical ACLR requirement of -45 dBc.  ***Proposal 8:***Adopt phase noise modelling in RAN1 studies to capture the distortion introduced by high power leakage from the DL sub-bands into the UL sub-bands. The phase noise models in TR 38.803 or those provided by RAN4 during the Rel-17 phase can be adopted as baseline models.  ***Proposal 9:***Adopt modelling of analog filtering, if present, in RAN1 link level studies to capture potential impacts to digital cancellation feasibility and performance.  To handle such enlarged dynamic range than typical wide area BS implementations, alternative solutions need to be considered to avoid losing sensitivity:  • One possibility is to introduce analog filtering before the ADC.  • Another possibility is to increase the bit width of the ADC.  • A combination of the above two types of solutions.  ***Proposal 10:***Adopt explicit digital filtering models in RAN1 link level studies to capture potential impacts to digital cancellation feasibility and performance.    *gNB digital self-interference cancellation solution*  ***Observation 3:*** The complexity of digital self-interference cancellation scales with the product of (1) the number of TX chains, (2) the number of RX chains and (3) the effective length of the multi-tap response of the environment and the analog RX frontends.  *Link-Level Studies*  ***Proposal 11:***Send an LS to RAN4 requesting feedback on various radio and antenna modelling aspects that are required for RAN1 to establish evaluation assumptions for link-level simulations. Request feedback on the following gNB aspects:   * Realistic net effect model that captures the essential behavior of a realistic DPD and PA combination with -45 dBc ACLR compliance, e.g., a net effect model based on a generalized memory polynomial * Simple model of crest 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 model for non-linearities in the gNB Rx chain, e.g., LNA, mixers, AGC * Phase stability of LO for downconversion of received signal * Characteristics of realistic analog filter for suppression of DL subbands to avoid saturation of ADC * Practical ADC aspects   + Dynamic range   + Impact on BS implementation of increased bitwidth   *Suitability of current base station implementations for SBFD*  ***Observation 4:*** For the low power BS class, such as the representative LA BS class, a single isolated BS can operate in the SBFD mode using existing hardware components and without the need of digital self-interference cancellation if antenna isolation of 80 dB is achieved.  ***Observation 5:*** Digital self-interference cancellation for MR BS SBFD operations needs to suppress not only TX direct leakage into the UL sub-bands but also spectrum regrowth caused by RX LNA nonlinearity and inter-carrier interference caused by oscillator phase noises. The complexity scaling and the cancellation performance of digital cancellation solutions need further study.  ***Observation 6:*** For the medium power BS class, such as the representative MR BS class, self-interferences may be addressed with (1) hardware component upgrades, whose cost, complexity, energy consumption and heat dissipation issues scale linearly with the number of TX/RX chains; or with (2) digital self-interference cancellation, whose cost, complexity, energy consumption and heat dissipation issues scale quadratically with the number of TX/RX chains.  ***Observation 7:*** For the medium power BS class, such as the representative MR BS class, self-interferences mitigation solutions via hardware component upgrades, digital self-interference cancellation, or combinations of both are needed even with 80 dB antenna isolation. With any of these approaches, the RX chains suitable for SBFD operation require more or better hardware, higher energy consumption, and higher heat dissipation than those suitable for conventional static TDD operation.  ***Observation 8:*** For the high-power BS class, such as the representative WA BS class, self-interference powers are far above what current typical WA BS hardware is designed for even with 80 dB antenna isolation. Either of the hardware component upgrade and digital cancellation approaches can result in substantial cost/complexity, energy consumption, or heat management issues.  **Coverage**  ***Observation 9:***A coverage metric based on the pathloss corresponding to a given certain bit rate is a good metric for system level simulations as it considers realistic beamforming and CLI, unlike the MPL obtained from link budget analysis.  ***Proposal 17:*** RAN1 to define a coverage metric as the target path loss corresponding to a certain (smoothed) average bit rate determined from system simulations: 10Mbps for DL and 1Mbps for UL. This is called “10 Mbps coverage” for DL and “1 Mbps coverage” for UL. |
| ZTE | **Coverage**  ***Proposal 13****: Consider the following methods for coverage evaluation for SBFD.*  ***Method#1:***  *Step1: Perform SLS for legacy TDD system and get the 5% SINR (SINR#1);*  *Step2: Perform LLS for legacy TDD system to get the target SINR (SINR#2), with which UE can achieve a certain bit rate in UL and DL;*  *Step3: Perform SLS for SBFD system and consider the SBFD interferences in the SLS to get the 5% SINR (SINR#3);*  *Step4: Perform LLS for SBFD system to get the target SINR (SINR#4), with which UE can achieve a certain bit rate in UL and DL;*  *Step5: Compare the gap (SINR#1 – SINR#2) with gap (SINR#3 – SINR#4) to determine if SBFD system can improve the coverage.*  ***Method#2:***  *Step1: Perform SLS for SBFD system and consider the SBFD interferences in the SLS to get the interference levels for the 5%-tile UE;*  *Step2: Perform LLS for SBFD system to get the target SINR, with which UE can achieve a certain bit rate in UL and DL;*  *Step3: Generate a link budget for MPL and input the interference levels in Step1 and target SINR in Step2 in the link budget;*  *Step4: Compare the MPL with legacy TDD system.* |
| Xiaomi | **Table 1: Summary of definition for output metrics**   |  |  |  | | --- | --- | --- | | Output metric | Definition | Source | | Coverage | The budget template defined for coverage enhancement can be used as a starting point. Self-interference and CLI should be reflected. | TR38.830 | |

### Summary

Regarding LLS methodology and the motivation of LLS in this SI,

* 1 company [Ericsson] provides the models for the TX chains, antenna coupling, and RX chains for typical BS implementations. Ericsson thinks these example models can be used in LLS to evaluate performance of self-interference suppression and to verify/justify assumptions used in system-level evaluations, or can be used to assess the suitability of current base station implementations for SBFD operation. Ericsson also proposes 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 link-level simulations. Request feedback on the following gNB aspects:
  + Realistic net effect model that captures the essential behavior of a realistic DPD and PA combination with -45 dBc ACLR compliance, e.g., a net effect model based on a generalized memory polynomial
  + Simple model of crest 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 model for non-linearities in the gNB Rx chain, e.g., LNA, mixers, AGC
  + Phase stability of LO for downconversion of received signal
  + Characteristics of realistic analog filter for suppression of DL subbands to avoid saturation of ADC
  + Practical ADC aspects
    - Dynamic range
    - Impact on BS implementation of increased bitwidth
* 1 company [Samsung] propose to consider the following simplified self-interference model for LLS
  + The self-interference seen at RX baseband chain is modeled as white Gaussian interference with the interference power. Its interference power is decided as in SLS
* 1 company [Huawei] thinks LLS can be used to evaluate link level algorithm for SBFD and dynamic/ flexible TDD enhancement.

Regarding coverage performance evaluation,

* 7 companies [Huawei, Samsung, Docomo, CATT, New H3C, Intel, Xiaomi, CMCC] propose 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.
* 1 company [Ericsson] proposes to define the coverage metric as the target path loss corresponding to a certain (smoothed) average bit rate determined from system simulations: 10Mbps for DL and 1Mbps for UL.
* 1 company [ZTE] proposes another method for coverage performance evaluation in addition to the evaluation methodology in TR 38.830.

Regarding the target channel for coverage performance evaluation,

* PUSCH [Huawei, Samsung, Intel, CMCC]
* PUCCH [Samsung]

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

Regarding gNB self-interference modelling in LLS used for coverage performance evaluation, the following two options can be considered:

* Opt 1: The self-interference seen at Rx baseband chain is modeled as white Gaussian interference, and the interference power is modelled in a similar way as in SLS.
* Opt 2: Generation of the self-interference signals and self-interference cancellation at the gNB are modelled in LLS, e.g., the following components need to be considered [Ericsson]
  + gNB Transmitter Modeling
    - Realistic net effect model that captures the essential behavior of a realistic DPD and PA combination to the base station ACLR requirements, e.g., a net effect model based on a generalized memory polynomial
    - Simple model of crest 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
  + gNB Receiver Modeling
    - Realistic model for non-linearities in the gNB Rx chain, e.g., LNA, mixers, AGC
    - Phase stability of LO for downconversion of received signal
    - Characteristics of realistic analog filter for suppression of DL subbands to avoid saturation of ADC
    - Practical ADC aspects, e.g., dynamic range, impact on BS implementation of increased bitwidth
  + gNB Antenna and self-interference channel

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

1 company proposes that, for link level simulation and Link budget analysis for coverage performance evaluation, the following options for inter-site gNB-gNB co-channel inter-subband CLI modelling can be considered.

* Opt 1: Inter-site gNB-gNB co-channel inter-subband CLI is modelled as an interference margin in the Link budget template. E.g., the interference margin can be obtained by the average IoT degradation due to Inter-site gNB-gNB co-channel inter-subband CLI in SLS.
* Opt 2: Separate gNB-gNB links are modelled in LLS for modelling inter-site gNB-gNB co-channel inter-subband CLI. Receiver algorithms (e.g., MMSE-IRC) can be used to mitigate the inter-site gNB-gNB co-channel inter-subband CLI.

This issue can be discussed later.

### 1st Round Proposals

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

For coverage performance evaluation for SBFD, use option 1 of the following options.

* Option 1: Take link level evaluation methodology in TR 38.830 (i.e., LLS + Link budget analysis) as starting point to evaluate the coverage performance (e.g., MPL, MCL, MIL) for SBFD.
* Option 2: Define the coverage metric as the target path loss corresponding to a certain (smoothed) average bit rate determined from system simulations: 10Mbps for DL and 1Mbps for UL. This is called “10 Mbps coverage” for DL and “1 Mbps coverage” for UL.
* Option 3:
  + Step1: Perform SLS for legacy TDD system and get the 5% SINR (SINR#1);
  + Step2: Perform LLS for legacy TDD system to get the target SINR (SINR#2), with which UE can achieve a certain bit rate in UL and DL;
  + Step3: Perform SLS for SBFD system and consider the SBFD interferences in the SLS to get the 5% SINR (SINR#3);
  + Step4: Perform LLS for SBFD system to get the target SINR (SINR#4), with which UE can achieve a certain bit rate in UL and DL;
  + Step5: Compare the gap (SINR#1 – SINR#2) with gap (SINR#3 – SINR#4) to determine if SBFD system can improve the coverage.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
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#### ***Initial proposal 3-1-2:***

Regarding gNB self-interference modelling in LLS used for coverage performance evaluation, the following two options can be considered:

* Opt 1: The self-interference seen at Rx baseband chain is modeled as white Gaussian interference, and the interference power is modelled in a similar way as in SLS.
* Opt 2: Generation of the self-interference signals and self-interference cancellation at the gNB are explicitly modelled in LLS, e.g., gNB transmitter modeling (e.g., model for DPD, PA, CFR), gNB receiver modeling (e.g., model for non-linearities in the gNB Rx chain, phase stability, practical ADC), self-interference channel, etc.

Companies are encouraged to provide comments in the table below.

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| **Company** | **Comment** |
| Intel | In this regards, we may prefer to wait for the reply from RAN4. |
| Ericsson | In response to Intel's comment, above, the reply LS from RAN4 will not include link-level aspects, since that was FFS in the agreement from last meeting:  **Agreement**  Regarding gNB self-interference modelling for system level simulation purpose, consider introducing ratio of self-interference (RSI) 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  …   * FFS: Model for link level simulations and relevant questions to ask RAN4   First of all, we think the primary use of gNB self-interference modelling is so that an accurate assessment of self-interfernce cancellation can be obtained (via link simulation). This is important for verifying what level of self-IC should be used as input for SLS, i.e., how many dB suppression should be assumed in SLS.  For accurate assessment of self-IC algorithms, it is important to model the spectral shape (frequency variation) of the self-interference, and to this end we have found that it is important to model memory effects in the transmit chain. Hence, in our view, Opt. 1 is not a useful option as it won't provide a realistic assessment of self-IC since it ignores the structure of the interference.  For Opt. 2, we think it should be reformulated. It is not necessary to have detailed modeling of each component of the Tx chain and of the Rx chain separately. A "net effect" model is sufficient for link simulations.  Finally, we think that it is necessary to send an LS to RAN4 to ask about what net-effect models shall be used.  Based on the above, we propose the following changes to the proposal: ***Initial proposal 3-1-2:*** Regarding gNB self-interference modelling in LLS ~~used for coverage performance evaluation,~~ the following ~~two options can be considered~~ should be discussed in this meeting:   * ~~Opt 1: The self-interference seen at Rx baseband chain is modeled as white Gaussian interference, and the interference power is modelled in a similar way as in SLS.~~ * ~~Opt 2:~~ Generation of the self-interference signals and self-interference cancellation at the gNB are explicitly modelled in LLS, e.g., gNB transmitter modeling (e.g., net-effect model for DPD, PA, CFR including memory effects), gNB receiver modeling (e.g., net-effect model for non-linearities in the gNB Rx chain, plus phase stability, practical analog filter, and practical ADC characteristics), self-interference channel etc.   Send an LS to RAN4 requesting a suitable net-effect model of the gNB transmitter and a suitable net-effect model of the gNB receiver. |
| New H3C | It is better to wait for RAN ‘s input. |

# Proposals for GTW

# References

1. RP-213591, New SI: Study on evolution of NR duplex operation, CMCC
2. RP-220633, Revised SID: Study on evolution of NR duplex operation, CMCC
3. R1-2205810 On deployment scenarios and evaluation methodology of NR full duplex Dell Technologies
4. R1-2205814 Evaluation methodolgy for NR duplex evolution Kumu Networks
5. R1-2205896 Evolution of NR duplex operation Huawei, HiSilicon
6. R1-2205936 Discussion on evaluation methodology for NR-duplex InterDigital, Inc.
7. R1-2205959 Discussion of evaluation on NR duplex evolution ZTE
8. R1-2205988 Discussion on evaluation on NR duplex evolution Spreadtrum Communications, BUPT
9. R1-2206038 Evaluation on NR duplex evolution vivo
10. R1-2206107 Discussion for Evaluation on NR duplex evolution New H3C Technologies Co., Ltd.
11. R1-2206237 Evaluation of UE-UE CLI for NR SBFD operation NEC
12. R1-2206321 Discussion on evaluation on NR duplex evolution OPPO
13. R1-2206397 Discussion on evaluation on NR duplex evolution CATT
14. R1-2206420 Deployment scenario and evaluation methodology for NR duplex evolution Samsung
15. R1-2206504 Discussion on evaluation on NR duplex evolution Sharp
16. R1-2206582 Evaluation of NR duplex evolution Intel Corporation
17. R1-2206641 Discussion on evaluation on NR duplex evolution Xiaomi
18. R1-2206857 Discussion on guardband evaluation of NR duplex evolution KT Corp.
19. R1-2206910 Discussion on evaluation on NR duplex evolution CMCC
20. R1-2206983 Deployment scenarios and evaluation methodology for NR duplex evolution MediaTek Inc.
21. R1-2207230 On Deployment scenarios and evaluation Methodology for NR duplex evolution Qualcomm Incorporated
22. R1-2207266 On the evaluation methodology for NR duplexing enhancements Nokia, Nokia Shanghai Bell
23. R1-2207334 Initial evaluation on NR duplex evolution Apple
24. R1-2207363 Study on Evaluation for NR duplex evolution LG Electronics
25. R1-2207405 Discussion on evaluation on NR duplex evolution NTT DOCOMO, INC.
26. R1-2207461 Evaluation of NR duplex evolution Ericsson
27. R1-2207571 Proposing New Energy Consumption Metric for SBFD Vodafone, China Telecom, Telecom Italia
28. R1-2207607 Additional considerations for NR Duplex evolution Charter Communications, Inc

# Appendix I: RAN1 agreements on evaluation on NR duplex evolution

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| **Deployment scenarios for SBFD**  Agreement  For discussion purpose for evaluation, 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 (static TDD operation) while the others use SBFD operation with the same SBFD subband configuration.   + Deployment Case 3-1: Only 1-layer is considered   + Deployment Case 3-2: 2-layer is considered * 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 (static TDD operation) while the other operator uses SBFD operation with the same SBFD subband configuration.   Note: This definition has no intention to preclude any potential solutions for SBFD in AI9.3.2  Note: SBFD subband configuration is from gNB perspective.  Agreement  For SBFD Deployment Case 1, at least consider the following scenarios for evaluation:   * For FR1,   + Indoor office (use Indoor office defined in TR38.802/TR38.901 as starting point)   + Urban macro (use Urban macro defined in TR38.802/TR38.901 as starting point)     - FFS: UE outdoor/indoor proportion, clustering, etc   + Optional: Dense Urban with 1-layer or 2-layer (use Dense Urban defined in TR38.802/TR38.901 as starting point)   + FFS: Rural * For FR2-1,   + Indoor office (use Indoor office defined in TR38.802/TR38.901 as starting point)   + Dense Urban Macro layer (use Dense Urban defined in TR38.802 as starting point)     - FFS: UE outdoor/indoor proportion, clustering, etc   + Optional: Dense Urban micro (use Dense Urban micro defined in TR38.802/TR38.901 as starting point) * FFS: Whether FR2-2 is considered or not in Rel-18.   Note: For optional scenarios, they can be captured in TR and it is up to each company to provide the results. The results can be used to draw conclusion/recommendation depending on the number of companies providing the results.  Agreement  For SBFD Deployment Case 4, at least consider the following scenarios for evaluation from RAN1 perspective:   * FR1: Urban Macro * FR2-1: Dense Urban Macro layer * FFS: UE outdoor/indoor proportion, clustering, etc * FFS: the grid shift between two networks, e.g., 0%, 100%   FFS: Indoor hotspot, Dense Urban Micro layer  **Interference modelling**  Agreement  For discussion for duplex evolution study (all agenda items), consider the following as RAN1’s common understanding:   * Co-channel interference: The interference is from the aggressor to the victim in the same carrier.   + Co-channel intra-subband interference: The interference is caused by transmission of the aggressor on a set of contiguous RBs in a carrier to reception of the victim on the same set of contiguous RBs in the same carrier.   + Co-channel inter-subband interference: The interference is caused by transmission of the aggressor in a first set of contiguous RBs in a carrier to reception of the victim in a second set of contiguous RBs in the same carrier, where the two contiguous RB sets are non-overlapping in frequency. * 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.   Note 1: ‘Co-channel’ here means ‘co-carrier’. ‘Adjacent-channel’ here means ‘adjacent-carrier’.  Agreement  For discussion for duplex evolution study (all agenda items), consider the following as the common understanding in RAN1 on the definition of interference types for SBFD operation:   * gNB self-interference (SI): Interference caused by DL transmission on a set of DL RBs in a carrier to UL reception on a set of UL RBs in the same carrier at the gNB side, where the two RB sets are non-overlapping in frequency. * 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) inter-site gNB-gNB co-channel intra-subband CLI: CLI caused by DL transmission of the aggressor gNB on a set of RBs in one carrier to UL reception of the victim gNB in a different site on the same set of RBs in the same carrier. * (inter-cell) co-site inter-sector co-channel intra-subband CLI: CLI caused by DL transmission of the aggressor gNB on a set of RBs in one carrier to UL reception of the victim gNB in another sector of the same site on the same set of RBs in the same carrier. * (inter-cell) UE-UE co-channel intra-subband CLI: CLI caused by UL transmission of the aggressor UE on a set of RBs in one carrier to DL reception of the victim UE on the same set of RBs in the same carrier. * (inter-cell) inter-site gNB-gNB co-channel inter-subband CLI: CLI caused by DL transmission of the aggressor gNB on a first set of RBs in a carrier to UL reception of the victim gNB in a different site on a second set of RBs in the same carrier, where the two RB sets are non-overlapping in frequency. * (inter-cell) co-site inter-sector co-channel inter-subband CLI: CLI caused by DL transmission of the aggressor gNB on a first set of RBs in a carrier to UL reception of the victim gNB in another sector of the same site on a second set of RBs in the same carrier, where the two RB sets are non-overlapping in frequency. * (intra-cell/inter-cell) UE-UE co-channel inter-subband CLI: CLI caused by UL transmission of the aggressor UE on a first set of RBs in a carrier to DL reception of the victim UE on a second set of RBs in the same cell or neighboring cell in the same carrier, where the two RB sets are non-overlapping in frequency. * 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.   + This includes adjacent-channel CLI between gNBs in the same and different sectors of the same site, i.e., co-site intra and inter-sector adjacent-channel CLI. * 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.   Note: Some of the interferences may not be used according to the deployment scenarios, e.g, whether the SBFD subband configurations are the same or different across gNBs.  Note: This does not imply we need to consider all the above interference types in evaluation for SBFD.  Agreement:  Regarding gNB self-interference modelling for system level simulation purpose, consider introducing ratio of self-interference (RSI) 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. RSI also takes into account the impact of Tx/Rx antenna element gain on self-interference. The RSI, 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.   * FFS: Model for link level simulations and relevant questions to ask RAN4 * FFS: details of gNB self-interference modelling using RSI in SLS. As one example based on per-RB-RSI, the gNB self-interference on a single receiver chain at UL RB *n* can be modelled as   + , wherein,     - is the gNB self-interference on a single receiver chain at UL RB *n* caused by DL transmission on DL RB *m.*     - *m* is the DL RB index in DL subbands.     - is gNB’s DL transmission power across all transmit chains at RB *m* (in dBm).     - is the per-RB-RSI.   + FFS: consider a statistical clutter model based on statistics of clutter strength and AoA. * The following should be asked to RAN4:   + What is the value range of RSI for each frequency range, and under what assumptions on the self-interference suppression means the value range of RSI is provided?     - RAN1 understands the RSI can be described per subband, per RB, or per subcarrier depending on the granularity of the frequency unit, and it is up to RAN4 to provide the RSI in which granularity.   + Whether it is possible for RAN4 to provide RAN1 the respective capabilities of different self-interference suppression means? e.g., is it possible to provide the separate estimates for spatial isolation, subband frequency isolation, beamform nulling/isolation, and digital cancellation, etc., as below?     - +…       * denotes the spatial isolation.       * denotes the suband frequency isolation between the Tx frequency unit *m* and the Rx frequency unit *n.*       * denotes the beamform nulling or beam isolation.       * denotes the digital cancellation capability.   + Whether it is possible to simplify the RSI as frequency flat model, and under which condition(s) the dependency of the RSI on frequency can be ignored?   + The feasibility of provided value range of RSI regarding factors such as blocking, AGC, etc.   + Does RSI have any dependency with the following factors or any other factors? What are the dependencies?     - gNB’s antenna aspects, e.g., the assumed antenna architecture, the number of transmit chains and receive chains, etc.     - Frequency aspects, e.g., the frequency distance between the Tx frequency unit *m* and the Rx frequency unit *n*,the number of RBs allocated for DL transmission, etc.     - Beam aspects, e.g., Tx/Rx beam-pair for FR1/FR2 especially for clutter echo, etc. * Note: RAN1’s consideration on the frequency locations and sizes of SBFD DL subband and SBFD UL subband assumed in SBFD operation can be provided to RAN4.   Agreement  For discussion of gNB-gNB and UE-UE co-channel inter-subband CLI modelling in system level simulation, RAN1 understands at least the following two aspects need to be considered:   * **Aspect 1:** The unwanted emissions due to Tx non-linearity at the transmitter of the aggressor from the allocated RBs to the non-allocated RBs in the same carrier. * **Aspect 2:** The receiver selectivity at the victim to receive the desired signal in the allocated RBs in the presence of the unwanted signals at the non-allocated RBs. (e.g. receiver blocking at the victim, overload of the receiver dynamic range, etc) * The following questions should be asked to RAN4: * Whether it is feasible to consider the above two aspects for gNB-gNB and UE-UE co-channel inter-subband CLI modelling in system level simulation? Are there any other aspects should also be taken into account? * For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of gNB-gNB link, where the DL frequency unit *m* and UL frequency unit *n* are in the same carrier and non-overlapping in frequency, and assuming the aggressor gNB transmits on the DL frequency unit *m* and the victim gNB receives on the UL frequency unit *n*,   + How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 1 (defined above) at the gNB transmitter?   + How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 2 (defined above) at the gNB receiver?   + How to model the above interferences for the following two cases:     - inter-site gNB-gNB co-channel inter-subband CLI     - co-site inter-sector co-channel inter-subband CLI * For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of UE-UE link, where the DL frequency unit *m* and UL frequency unit *n* are in the same carrier and non-overlapping in frequency, and assuming the aggressor UE transmits on the UL frequency unit *n* and the victim UE receives on the DL frequency unit *m*,   + How to model the interference from UL frequency unit *n* to DL frequency unit *m* due to Aspect 1 (defined above) at the UE transmitter?   + How to model the interference from UL frequency unit *n* to DL frequency unit *m* due to Aspect 2 at the UE receiver?   FFS: Usage of the above model provided by RAN4 in the evaluation  Agreement  Regarding gNB-gNB and UE-UE adjacent-channel CLI modelling for system level simulation, RAN1 understands at least the following aspects need to be considered:   * Aspect 1: The unwanted emissions due to Tx non-linearity at the transmitter of the aggressor from the allocated RBs in one carrier to the non-allocated RBs in the adjacent carrier. * Aspect 2: The receiver selectivity at the victim to receive the desired signal in the allocated RBs in one carrier in the presence of the unwanted signals at the non-allocated RBs in the adjacent carrier. (e.g. receiver blocking at the victim, overload of the receiver dynamic range, etc)   The following questions should be asked to RAN4:   * Whether it is feasible to consider the above two aspects for gNB-gNB and UE-UE adjacent-channel CLI modelling in system level simulation? Are there any other aspects should also be taken into account? * For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of gNB-gNB link, where the DL frequency unit *m* and UL frequency unit *n* are in adjacent carriers and non-overlapping in frequency, and assuming the aggressor gNB transmits on the DL frequency unit *m* and the victim gNB receives on the UL frequency unit *n*,   + How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 1 (defined above) at the gNB transmitter?   + How to model the interference from DL frequency unit *m* to UL frequency unit *n* due to Aspect 2 (defined above) at the gNB receiver?   + How to model the above interferences for the following cases:     - the two gNBs are from the same sector of the same site in adjacent carriers, i.e., co-site co-sector gNB-gNB adjacent-channel CLI     - the two gNBs are from different sectors of the same site in adjacent carriers, i.e., co-site inter-sector gNB-gNB adjacent-channel CLI     - the two gNBs are from different sites in adjacent carriers, i.e., inter-site gNB-gNB adjacent-channel CLI   + Whether it is feasible to define a similar interference ratio as BS-BS ACIR in TR38.828 but in the subband of the adjacent carrier, with finer granularity (e.g., per subband or per RB), to represent the overall effect of the Aspect 1 and Aspect 2 described above?     - For example, whether it is feasible to define gNB-gNB-adjacent-channel-per-RB/subband interference ratio as the ratio of the power transmitted by the aggressor gNB on DL frequency unit m to the interference received by the victim gNB on UL frequency unit *n*? If it is feasible, then what is the value range of the gNB-gNB-adjacent-channel-per-RB/subband interference ratio for each frequency range? * For a specific pair of DL frequency unit *m* (e.g., subband/RB *m*) and UL frequency unit *n* (e.g., subband/RB *n*) of UE-UE link, where the DL frequency unit *m* and UL frequency unit *n* are in adjacent carriers and non-overlapping in frequency, and assuming the aggressor UE transmits on the UL frequency unit *n* and the victim UE receives on the DL frequency unit *m*,   + How to model the interference from UL frequency unit n to DL frequency unit *m* due to Aspect 1 (defined above) at the UE transmitter?   + How to model the interference from UL frequency unit n to DL frequency unit *m* due to Aspect 2 at the UE receiver?   + Whether it is feasible to define a similar interference ratio as UE-UE ACIR in TR38.828 but in the subband of the adjacent carrier, with finer granularity (e.g., per subband or per RB), to represent the overall effect of the Aspect 1 and Aspect 2 described above?     - For example, whether it is feasible to define UE-UE-adjacent-channel-per-RB/subband interference ratio as the ratio of the power transmitted by the aggressor UE on UL frequency unit n to the interference received by the victim UE on DL frequency unit m? If it is feasible, then what is the value range of the UE-UE-adjacent-channel-per-RB/subband interference ratio for each frequency range?   FFS: How to make use of the interference model in RAN1  **Performance metrics**  Agreement  At least the following metrics are considered for SBFD and dynamic/flexible TDD evaluation.   * DL/UL UPT or user throughput (CDF or {mean, 5%, 50%, 95%}) using SLS * Latency (CDF or {mean, 5%, 50%, 95%}) using SLS * Resource utilization using SLS * DL/UL received SINR using SLS * Coverage metric   + FFS: MPL to achieve a certain bit rate in UL and DL * FFS: definitions of the above metrics * FFS: other metrics   **SBFD subband and slot configurations**  Agreement  For performance evaluation and comparison between baseline legacy TDD operation and SBFD operation under SBFD Deployment Case 1 (Non-coexistence case with single SBFD subband configuration), consider the following alternatives:   * Alt 2 (No SBFD DL subband in the slots/symbols that correspond to UL slots/symbols in legacy TDD):   + Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]   + SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth. * Alt 4 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):   + Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]   + SBFD: Frame structure#3 (XXXXX), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth. * Alt 1 (No SBFD DL subband in the slots/symbols that correspond to UL slots/symbols in legacy TDD):   + Legacy TDD: Static TDD UL/DL configuration with {DDDSU}, where S=[12D:2G:0U]   + SBFD: Frame structure#1 (DXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth. * Alt 3 (strive for the same UL/DL resource ratio between Legacy TDD and SBFD):   + Legacy TDD: Static TDD UL/DL configuration with {DDSUU}, where S=[12D:2G:0U]   + SBFD: Frame structure#2 (XXXXU), where X denotes a SBFD slot. In time domain, SBFD UL subband spans all the symbols in a SBFD slot. In frequency domain, SBFD UL subband is about [20%] of the channel bandwidth.   FFS: whether dynamic TDD can optionally be used for legacy TDD for comparison.  Agreement  For SBFD evaluation, consider the following for SBFD subband configurations:   * SBFD Subband configuration#1 with {DUD} pattern, which means one SBFD slot consists of one UL subband at the center of the channel bandwidth and two DL subbands at two sides of the channel bandwidth. * SBFD Subband configuration#2 with {DU} pattern, which means one SBFD slot consists of one UL subband at one side of the channel bandwidth and one DL subband at the other side of the channel bandwidth. * Use the following parameters for description of SBFD subband configuration in evaluation assumptions:   + 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   **Traffic model**  Agreement  Regarding traffic model for SBFD and dynamic/flexible TDD evaluation, at least FTP3 is considered. 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.   * FFS: other traffic models, e.g., XR, VoIP * FFS: Packet size, traffic load, ratio of DL/UL traffic * FFS: additionally consider different amount of input traffic at least for adjacent-channel~~/co-channel~~ coexistence studies   **Antenna configuration**  Agreement  For evaluation of legacy TDD operation, BS uses the same antenna array for downlink transmission and uplink reception, we can call it shared-Tx/Rx antenna array for description of evaluation assumption.  Agreement  For evaluation of SBFD operation, BS uses separate panels for simultaneous downlink transmission and uplink reception, we can call it separate-Tx/Rx antenna array for description of evaluation assumption.   * Companies can report the separation of the Tx panel and Rx panel assumed in their simulation. * Companies can report how the antenna elements are used for transmission or reception in a slot if BS does not perform simultaneous downlink transmission and uplink reception.   Agreement  For evaluation and comparison between SBFD and legacy TDD, assume the total number of TxRUs of the antenna array for SBFD is the same as the total number of TxRUs of the antenna array for legacy TDD. Regarding antenna elements, both of the two options can be used.   * Opt 1: The total number of antenna elements of the antenna array for SBFD is the same as the total number of antenna elements of the antenna array for legacy TDD. * Opt 2: The total number of antenna elements of the antenna array for SBFD is two times of the total number of antenna elements of the antenna array for legacy TDD. * Companies report which option is assumed in their simulation.   **Channel model**  Agreement  For gNB-gNB co-channel/adjacent-channel channel model and UE-UE co-channel/adjacent-channel channel model in RAN1 SLS,   * Large scale fading (e.g., path loss, penetration loss, shadowing) should be modelled, and companies report whether small scale fading (e.g., fast fading including antenna gain) is also modelled in their simulation. * 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 modelled. * FFS: how to model realistic LOS probability for gNB-gNB and UE-UE channel model. * FFS: How to set aligned channel model amongst companies for SLS calibration (if needed).   Agreement  For gNB-gNB channel model, reuse gNB-to-UE channel model in TR 38.901 with necessary modification   * Replacing the UE’s antenna height with gNB’s antenna height, updating the angular spread * FFS: whether/how to update LOS probability. * FFS: Other details and necessary modifications   **Other issues**  Agreement  For SBFD simulation, consider 4GHz for FR1 and 30GHz for FR2-1. |

# Appendix II: Performance Evaluation Results

## Preliminary evaluation results for link budget analysis (for SBFD)

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| **Company** | **Proposals** |
| CMCC |  |
| Huawei | **Indoor office**  *gNB-gNB co-channel inter-subband or adjacent-channel CLI:*  ***Observation 1****: For InH, (inter-site) gNB-gNB co-channel inter-subband or adjacent-channel CLI is far less than UE-gNB UL signal. And therefore, a high UL SINR can be obtained even with the gNB-gNB CLI.*  *UE-UE co-channel inter-subband or adjacent-channel CLI*  ***Observation 2****: For InH, UE-UE co-channel inter-subband or adjacent-channel CLI is much less than gNB-UE DL signal. The DL SINR is acceptable even with the UE-UE CLI.*  *gNB self-interference:*  ***Observation 3****: For InH, it suffers from large gNB self-interference.*  *Blocking interference*  ***Observation 4****: For InH, it suffers from serious gNB-gNB blocking interferences and UE-UE blocking interferences.*  ***Proposal 33****: Capture the link budget results in Table 1-6 and the following observations into TR 38.858:*   * *(Inter-sector) gNB-gNB co-channel inter-subband or adjacent-channel CLI and UE-UE co-channel inter-subband or adjacent-channel CLI can be negligible in InH.* * *Further enhancements are required to suppress gNB self-interference in InH.* * *Further enhancements are required to handle the gNB-gNB and UE-UE blocking interferences in InH.*   **Dense Urban Macro layer**  *gNB-gNB co-channel inter-subband or adjacent-channel CLI:*  ***Observation 5****: In Dense Urban Macro layer, (inter-site) gNB-gNB co-channel inter-subband or adjacent-channel CLI is comparable with UE-gNB UL signal.*  *gNB self-interference:*  ***Observation 6****: In Dense Urban Macro layer, it suffers from large gNB self-interference.*  *Blocking interference*  ***Observation 7****: In Dense Urban Macro layer, it suffers from serious gNB-gNB and UE-UE blocking interferences.*  ***Proposal 34****: Capture the link budget results in Table 7-10 and the following observations into TR 38.858:*   * *UE-UE co-channel inter-subband or adjacent-channel CLI can be negligible in Dense Urban Macro layer.* * *Further enhancements are required to handle (inter-sector) gNB-gNB co-channel inter-subband or adjacent-channel CLI in Dense Urban Macro layer.* * *Further enhancements are required to handle gNB self-interference in Dense Urban Macro layer.* * *Further enhancements are required to handle the gNB-gNB and UE-UE blocking interferences in Dense Urban Macro layer.*   **Urban Macro**  *gNB-gNB co-channel inter-subband or adjacent-channel CLI:*  ***Observation 8****: In UMa, (inter-site) gNB-gNB co-channel inter-subband or adjacent-channel CLI is comparable with UE-gNB UL signal.*  *Blocking interference*  ***Observation 9****: In UMa, it suffers from serious gNB-gNB and UE-UE blocking interferences.*  ***Proposal 35****: Capture the link budget results in Table 11-13 and the following observations into TR 38.858:*   * *UE-UE co-channel inter-subband or adjacent-channel CLI can be negligible in UMa.* * *Further enhancements are required to handle (inter-sector) gNB-gNB co-channel inter-subband or adjacent-channel CLI in UMa.* * *Further enhancements are required to handle gNB self-interference in UMa.* * *Further enhancements are required to handle the gNB-gNB and UE-UE blocking interferences in UMa.*   **HetNet**  ***Observation 10****: In HetNet, gNB-gNB co-channel intra-subband CLI from UMa layer to InH layer is comparable with UE-gNB UL signal in InH layer.*  ***Proposal 36****: Capture the link budget results in Table 14 and the following observations into TR 38.858:*   * *UE-UE co-channel intra-subband CLI can be negligible in HetNet.* * *Further enhancements are required to suppress the gNB-gNB co-channel intra-subband CLI in HetNet.* |

## Preliminary evaluation results for link level simulation (for SBFD)

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| **Company** | **Proposals** |
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| Huawei | **Dense Urban Macro layer**  *UL UPT*  ***Observation 11:*** *For Dense Urban Macro scenario, the inter-site gNB-gNB co-channel inter-subband CLI dominates the UL interference at SBFD slots suffered by gNB.*  ***Observation 12:*** *For Dense Urban Macro scenario, E-MMSE-IRC receiver achieves mean UL UPT closer to the theoretical one under each frame structures for SBFD than MMSE-IRC receiver, as well as more significant UL coverage gain than MMSE-IRC receiver, especially at high RU.*  ***Proposal 37****: Capture the system level simulation results in Fig. 11-12 under Dense Urban Macro layer and the following observations into TR 38.858:*   * *E-MMSE-IRC receiver is beneficial to suppress the inter-site gNB-gNB co-channel inter-subband CLI.*   *gNB blocking interference*  ***Observation 13:*** *For Dense Urban Macro scenario, the blocking issue is serious at gNB side.*   * *At gNB side, the gNB-gNB co-channel intra-subband CLI almost always exceed the blocking requirement (-43dBm).*   ***Proposal 38****: Capture the system level simulation results in Fig. 13 under Dense Urban Macro layer and the following observations into TR 38.858:*   * *Study the potential solutions to suppress blocking interferences, e.g., coordinated beamforming, etc.*   **Urban Macro**  *UL UPT*  ***Observation 14:*** *For Urban Macro scenario, the inter-site gNB-gNB co-channel inter-subband CLI dominates the UL interference at SBFD slots suffered by gNB.*  ***Observation 15:*** *For Urban Macro scenario, E-MMSE-IRC receiver achieves mean UL UPT closer to the theoretical one under each frame structures for SBFD than MMSE-IRC receiver, as well as more significant UL coverage gain than MMSE-IRC receiver.*  ***Observation 16:*** *The UL coverage gain obtained by E-MMSE-IRC in Urban Macor scenario is less than that in the Dense Urban Macro layer.*  ***Proposal 39****: Capture the system level simulation results in Fig. 14-15 under Urban Macro scenario and the following observations into TR 38.858:*   * *E-MMSE-IRC receiver is beneficial to suppress the inter-site gNB-gNB co-channel inter-subband CLI.*   *gNB blocking interference*  ***Observation 17:*** *Under Urban Macro scenario, the blocking issue is serious at gNB side.*   * *At gNB side, there are 75% to 90% gNB-gNB co-channel intra-subband CLI exceed the blocking requirement at gNB side (-43dBm).*   ***Proposal 40****: Capture the system level simulation results in Fig. 16 under Urban Macro scenario and the following observations into TR 38.858:*   * *Study the potential solutions to suppress blocking interferences, e.g., coordinated beamforming, etc.* |
| DOCOMO | ***Observations*** :   * FR1 eMBB : no remarkable MPL degradation is observed when guard band is 5 PRBs and 25 PRBs with 10,20, 30 dB PSD diference. * FR1 VoIP : MPL degradation of 3.0 dB, 0.6 dB are observed for 5 PRBs and 25 PRBs guard band with 40 dB PSD difference.   + Larger bandwith of interference signals is one of the reasons for the degradation compared with eMBB * FR2 eMBB : MPL 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 is higher, wider guard band or small PSD difference is required   + PSD difference and guard bandwidth are key parameters for the evaluation * FR2 VoIP : MPL degradation of 3.4 dB, 0.3 dB are observed for 1 PRB and 6 PRBs guard band with 30 dB PSD difference, respectively. |
| MediaTek | To assess the uplink coverage gain and the impact of CLI on it, we follow the link budget analysis methodology provided in TR38.830 which is a study report of Rel-17 coverage enhancement. The analysis methodology is given as below:   * Obtain CCI and CLI interference density values from SLS, which would be different for different DL RU. * Find out minimum MCS combinations required in SBFD and pure uplink slots to support target PUSCH data rate of 1 Mbps (from TR38.830). * For the minimum SINRs required to support the above minimum MCSs, compute the coverage values in SBFD and UL slots according to link budget analysis method in TR 38.830 and find the minimum one as the uplink coverage.   ***Observation 9:*** SBFD slot has higher UL interference compared to UL-only slot due to gNB CLI, and the UL interference increases with the DL RU.  ***Observation 10***: For the considered scenario, coverage gain from Strategy#1 can be achieved if the ratio of sum of interference and noise in SBFD slots and UL-only slot is less than 5.36dB.  ***Observation 11***: For the considered scenario, SINR gain from Strategy#2 is (1+2/b^2 ). TB repetition in SBFD and UL-only slots helps to improve the uplink SINR and coverage.  ***Observation 12***: Different strategies achieve maximum coverage under different DL load conditions;   * + Strategy#1 and #3 achieve maximum coverage if CLI is negligible.   + Strategy#3 achieves maximum coverage under low and medium DL load conditions.   + Strategy#2 achieves maximum coverage under high DL load conditions.   ***Proposal 5****:* The following can be assumed for coverage evaluation:   * + Strategy#3 is used for coverage enhancement when DL RU is low or medium.   + Strategy#2 is used for coverage enhancement when DL RU is high. |
| InterDigital | ***Observation 2:*** *DL throughput performance suffers considerably as a result of intra-subband CLI when there is an overlap in DL and UL subbands.* |
| Intel | ***Observation 1:*** Without self-interference modelling, 2~3dB link-level performance gain can be observed by doubling the repetition levels for PUSCH transmission in both FR1 and FR2. |

## Preliminary evaluation results for system level simulation

#### For SBFD

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| **Company** | **Proposals** |
| CMCC |  |
| Huawei | **Minimum SNR requirements**  ***Observation 18:*** *The PUSCH performance is degraded significantly by the gNB-gNB CLI when baseline scheme is adopted*   * *With 4 gNB interferers and 10dB INR for each CLI, 9dB performance deterioration is observed compared to the case without interference*   ***Observation 19:*** *The PUSCH performance can be improved when enhanced scheme is adopted*   * *With 4 gNB interferers and 10dB INR for each CLI, only 1.2dB performance deterioration is observed compared to the case without interference*   ***Proposal 41****: Study the potential solutions for gNB-gNB CLI handling based on muting resources.* |
| ZTE | **Indoor Hotspot**  ***Observation 1****: For Indoor Hotspot scenarios, compared with legacy TDD,*   * *DL throughput degradation for SBFD is observed in case higher RU and lower RU.* * *UL throughput gain for SBFD is observed in case of higher RU and lower RU. The gain for the case of higher RU is larger than that for lower RU.* * *DL latency is increased and UL latency is reduced.*   **Dense urban**  ***Observation 2****: For Dense urban scenarios, compared with legacy TDD,*   * *DL throughput degradation for SBFD is observed in case higher RU and lower RU.* * *UL throughput gain for SBFD is observed in case of higher RU and lower RU.* * *DL latency is increased and UL latency is reduced.* |
| Ericsson | **System evaluation for single operator networks in FR1**  *Urban Macro*  ***Observation 11****:* Proposed static TDD 2UL network provides similar but slightly lower DL coverage compared to an SBFD network with double-sized antenna at low medium and high loads but not more than ~2 dB  ***Observation 12****:* Proposed static TDD 2UL network provides better performance in UL coverage compared to an SBFD network with double-sized antenna (Opt 2 in the agreement) at medium and high loads.  ***Observation 13****:* For single operator Urban Macro scenario, UL performance gains of SBFD network in both coverage and mean and cell-edge user throughputs decreases as the load in the network increases.  ***Observation 14****:* For single operator Urban Macro scenario, the proposed Static TDD 2UL network provides comparable performance in DL as an SBFD network and superior UL performance in terms of coverage, mean and cell-edge user throughput  *Indoor*  ***Observation 15****:* Indoor simulation results shows that SBFD and static TDD 2UL networks provides clearly better mean and cell-edge user throughput in the UL compared to the reference static TDD network, at the cost of decreased DL performance.  ***Observation 16****:* In indoor case, SBFD and static TDD 2UL networks clearly outperform the reference static TDD network in terms of mean and cell-edge user data latency in UL, while behaves worse in DL.  ***Observation 17****:*For single operator Urban Macro deployments, inter-sector, inter-site, UE-UE and self- interference has marginal impact on DL performance.  ***Observation 18****:* For single operator Urban Macro deployments, the UL performance deterioration due to inter-sector and inter-site (in case of 100% LoS) interference dominates over self-interference.  **System evaluation for two operator networks coexisting in FR1**  ***Observation 19****:* Different loads in the aggressor network (Static TDD) does not impact the mean DL resource utilization of the SBFD network (at low load) for both grid shifts 0% and 100%. SBFD networks with same area as the static TDD network has increased mean DL resource utilization.  ***Observation 20****:* SBFD operation with “same area (Opt 1)”, “same gain (Opt 2)” and “same area UL same gain” generally results in lower mean UL resource utilization (at low load) for low, medium and high loads in the aggressor static TDD network for both grid shifts 0% and 100%. At high loads in co-located BSs, the resource utilization is comparable to a static TDD network coexisting with a static TDD network.  ***Observation 21****:* For a two-operator scenario, UL gains both for SBFD and the proposed static TDD 2UL network in terms of throughput (mean and 5%tile) and coverage diminish as the load of the aggressor network increases.  ***Observation 22****:* For higher power BS class in Urban Macro scenario, system level simulations have shown that there is little to no improvement in UL coverage or throughput performance by deploying an SBFD network as opposed to using a simple scheme such as static TDD 2UL in both single and multi-operator scenario.  ***Observation 23****:* For isolated indoor deployments, system level simulations show that similar UL latency improvements can be achieved by deploying an SBFD network as well as using simple schemes such as static TDD 2UL. However, there is a need to align and ensure the scenario assumed for Indoor is realistic by deploying, for example, an Urban Macro layer.  ***Proposal 26:*** RAN1 to agree the system level simulation parameters for Urban Macro and Indoor office listed in Annex B. |
| Qualcomm | **Indoor Office Deployment for FR1**  ***Observation 18***: DL perceived throughput of SBFD InH Option1 is lower than TDD. However, SBFD InH option 2 outperforms TDD due to increases antenna size and reduced blocking (reduced downlink duty cycle in SBFD)  ***Observation 19***: UE cross link did not impact the dense indoor layout due to the transmit power control.  ***Observation 20***: Inter-gNB cross link interference has minimal impact on the uplink SBFD performance. The impact is very low due to InH nodes being ceiling mounted and their antennas are facing downwards.  ***Observation 21:*** Considering the large spatial isolation and low Tx power for InH, the self-interference is not a problem for uplink reception. However, this is based on clutter modeling which may cause a significant impact on UL.  ***Proposal 29:*** RAN1 to study clutter modelling for realistic outcome of SBFD evaluation.  **Urban Macro Deployment for FR1**  *High load scenario*  ***Observation 22***: Like InH, SBFD Option 1 experiences lower downlink UPT as compared to TDD in UMa Layout, due to reduction in the antenna size  ***Observation 23***: Option 2 “without inter-UE CLI” case exhibits similar DL UPT of TDD for a fraction of UEs, and outperforms TDD for the rest of the UEs because of downlink Duty cycle improvement.  ***Observation 24***: In SBFD Option1 and Option2 “With inter-UE CLI”, degradation in downlink UPT is observed compared to case “w/o inter-UE CLI”  ***Observation 25***: SBFD “Without CLI” observes gain in the uplink UPT as compared to TDD because of uplink duty cycle improvement.  ***Observation 26***: Option 2 combats the uplink outage as compared to Option1 in High Load because of the antenna gain.  ***Observation 27***: Option 2 experiences lower gNB cross link interference as compared to Option1 because of increased flexibility to steer the aggressor gNB beams in the elevation.  ***Observation 28***: Without considering inter-gNB CLI, up to 5dB of coverage gain of SBFD is observed compared to TDD. However, with modeling inter-gNB CLI, the UL reception of some UEs are impacted when it is aligned with the inter-gNB CLI. Further inter-gNB CLI mitigation is beneficial to protect UL reception of these UEs.  *Medium load scenario*  ***Observation 29:*** The impact of inter-gNB and inter-CLI scales with the traffic load.  ***Observation 30:*** The UL outage is reduced with lower traffic load.  **FR2 Initial Performance Evaluation**  *subband non-overlapping full duplex*  ***Observation 31***: The downlink and uplink perceived throughput both have improved in case of SBFD with smaller file size. This is because duty cycle in SBFD is 100% (i.e., every slot has DL and UL resources), as compared to TDD where DL duty cycle is 80% and UL duty cycle is 20%.  ***Observation 32***: For the favorable DL and UL cases, SBFD can provide up to 46% performance gain for UL UPT for small file size such as 250B, and can provide up to 11.5% gain for DL UPT for small file size such as 10KB compared with legacy TDD. In addition, both high and low loading levels and both antenna configuration options can achieve good performance gain in terms of UL UPT with small file size.  *fully overlapping full duplex*  ***Observation 33***: The downlink perceived throughput for low load bursty traffic has ~2.6x performance gains compared with half duplex SU on the median DL UPT and ~2x performance gains compared with half duplex MU on the median DL UPT. The gains are largely a product of increased time domain resources and reduced transmission latencies enabled by full duplex.  ***Observation 34:*** The downlink perceived throughput for low load bursty traffic could achieve better performance with 110 dB or better self-interference isolation value with good isolation.  ***Observation 35:*** The downlink perceived throughput for high load bursty traffic has ~3.6x performance gains compared with half duplex SU on the median DL UPT and ~1.6x performance gains compared with half duplex MU on the median DL UPT. The sources of gain include the increased time domain resources (slot format of DDDDUUUU is used for baseline TDD half-duplex simulations) as well as decreased latencies due to slot format flexibility of full duplex. Larger performance gains are observed over baseline half duplex SU at high load system.  ***Observation 36:*** The downlink perceived throughput for high load bursty traffic could achieve better performance with 110 dB or better self-interference isolation value with good isolation.  ***Observation 37:*** Full duplex will improve the DL perceived throughput for both low load and high load systems and larger gains can be achieved at high loads.  ***Observation 38:*** Better isolation at the base station for full duplex mode can boost the downlink performance gain.  ***Observation 39***: The uplink perceived throughput for low load bursty traffic has ~2x performance gains compared with half duplex SU on the median DL UPT. The main sources of gain are the increased (2x) time domain resources as well as the slot format flexibility offered by full duplex (DDDDUUUU is used for baseline TDD half-duplex simulations).  ***Observation 40:*** Compared to DL, where the self-interference impact is indirect, UL is more sensitive to self-interference and isolation of 120 dB is needed to achieve ideal full duplex performance.  ***Observation 41:*** MU performance is limited at low loads by the availability of UEs to schedule (dynamic) while the SINR cost/loss is fixed due to half the array gain.  ***Observation 42***: There are similar observations for the uplink perceived throughput for high load bursty traffic. Larger performance gains are observed over baseline half duplex SU at high loads.  ***Observation 43***: Full duplex will improve the UL perceived throughput for both low load and high load systems and larger gains can be achieved in high load system.  ***Observation 44***: UL is more sensitive to self-interference and better isolation is needed to achieve ideal full duplex performance.  ***Observation 45***: gNB full duplex yields different types of advantages over half duplex   * Among them, the lower latency benefit from dynamic TDD (facilitated by full duplex) is a dominant source of gain especially at low loads * Spatial (DL-UL) multiplexing benefits are clearly seen at both low and high loads, although the percentage of true FD slots is limited * Larger gain at high loads is observed due to queuing delays incurred by the baseline * It is critical to limit self-interference to preserve full duplex gains   ***Observation 46***: The current performance results are based on fully overlapping full duplex. Subband full duplex results and also updated fully overlapping full duplex results will be provided next time. |
| vivo | **SBFD deployment case 1**  *Small packet size*  ***Observation 1****: For FR1 InH, FTP traffic with small packet size (0.1Mbyte) in deployment case 1,*   * + *Compared to legacy TDD with DDDSU, SBFD with XXXXU having more UL resources can significantly improve the UL UPT, accordingly, some DL UPT is degraded.*   + *Compared to legacy TDD with DDDSU, SBFD with XXXXX with the same DL/UL resource ratio can slightly improve the DL and UL UPT with two times antenna element number.*   + *With the same frame structure, SBFD with two times antenna element number of that for legacy TDD achieve better DL and UL UPT compared to SBFD with the same antenna element number of that for legacy TDD.*   *Large packet size*  ***Observation 2:*** *For FR1 InH, FTP traffic with large packet size (0.5Mbyte) in deployment case 1,*   * + *Compared to legacy TDD with DDDSU, SBFD with XXXXU with the increased UL resources can significantly improve the UL UPT, accordingly, some DL UPT degradation is observed.*   + *Compared to legacy TDD with DDDSU, SBFD with XXXXX with the same DL/UL resource ratio achieve higher DL UPT and slightly lower UL UPT, with two times antenna element number.*   + *With the same frame structure, SBFD with two times antenna element number of that for legacy TDD achieve better DL and UL UPT compared to SBFD with the same antenna element number of that for legacy TDD.*   **SBFD Deployment case 2**  *Small packet size*  ***Observation 3:*** *For FR1 InH, FTP traffic with small packet size (0.1Mbyte) in deployment case 2,*   * + *Compared to legacy TDD with DDDSU, SBFD with flexible sub-band size can significantly improve the UL UPT and also achieve higher DL UPT with two times antenna element.*   *Large packet size*  ***Observation 4:*** *For FR1 InH, FTP traffic with large packet size (0.5Mbyte) in deployment case 2,*   * + *Compared to legacy TDD with DDDSU, SBFD with flexible sub-band size can significantly improve both the DL and UL UPT.*   + *Compared to SBFD in deployment case 2 with small packet size, larger performance gain for DL and UL UPT over legacy TDD can be obtained.*   **Dynamic/flexible TDD**  *Small packet size*  ***Observation 5:*** *For FR1 InH, FTP traffic with small packet size (0.1Mbyte) in dynamic/flexible TDD,*   * + *Compared to legacy TDD with DDDSU, Dynamic/flexible TDD operation can achieve slightly higher DL UPT and significantly improve the UL UPT.*   *Large packet size*  ***Observation 6****: For FR1 InH, FTP traffic with large packet size (0.5Mbyte) in dynamic/flexible TDD,*   * + *Compared to legacy TDD with DDDSU, dynamic/flexible TDD can significantly improve the UL UPT.*   + *Compared to dynamic/flexible TDD with small packet size, larger performance gain for DL and UL UPT over legacy TDD can be obtained.* |
| OPPO | ***Observation 1:*** *The evaluations of Alt-1 and Alt-2 show that UL subband over DL symbols can increase UL throughput and UL UPT, generally at the cost of decreasing the DL throughput and DL UPT, where*   * *The impacts to DL/UL throughputs almost follow the DL/UL resource ratio;* * *The benefit on UL UPT is more outstanding than the one on UL throughput.* |
| MediaTek | **Inter-gNB CLI**  ***Observation 3:*** SBFD improves uplink latency by up to 93.1% (54.6%) in InH (UMa) scenario.  ***Observation 4:*** CCI dominates the UL interference in InH scenario, and gNB CLI dominates it in UMa scenario.  ***Observation 5:*** SBFD can improve average UL UPT by 140.5% (50%) in InH (UMa) scenario.  ***Observation 6:*** In InH scenario, gNB CLI has limited impact on average UL UPT performance. It reduces average UPT by maximum 0.4% when RU is 70%.  ***Observation 7:*** gNB CLI has severe impact on average UL UPT in UMa scenario, which can reduce average UL UPT by up to 9.1% when RU 70%.  **Inter-UE CLI**  ***Observation 8:*** Inter-UE CLI has significant impact to the DL performance. |
| LG | ***Observation 1:*** *In the deployment scenario of Urban Macro and Dense Urban with macro layer only, UL performance of SBFD is enhanced compared to the legacy TDD due to the increase of UL transmission opportunities.*  ***Observation 2:*** *In the deployment scenario of Urban Macro and Dense Urban with macro layer only, DL performance of SBFD is similar to or decreased compared to the legacy TDD due to the reduction of DL resources.* |
| Spreadtrum, BUPT | ***Observation 1:*** Performance degradation caused by gNB-gNB CLI is observed for urban macro scenarios  ***Observation 2:*** SI cancellation capability has a great impact on the performance of geometry in urban macro scenario.  ***Observation 3:*** LoS probability of gNB-gNB and UE-UE channel model plays an important part in geometry SINR in urban macro.  ***Observation 4:*** Performance degradation caused by UE-UE CLI is observed for indoor scenarios.  ***Observation 5:*** SI is negligible with 105dB SIR on the performance of geometry in indoor office scenario. |
| Xiaomi | ***Observation 3:*** When UL subband is introduced in DL slot, UL user throughput is improved significantly:   * Degradation of DL user thoughput is also observed, which depends on the UL subband configuration. * In ratio, improvement of UL performance is much more than the degradation of DL performance. * Better self-interference isolation achieves higher UL user throughput.   ***Observation 4:*** When UL subband is introduced in DL slot, UL lateny can be reduced significantly:   * Increasement of DL latency is also observed, which depends on the UL subband configuration. * Better self-interference isolation brings lower UL latency.   ***Observation 5:*** When UL subband is introduced in DL slot, UL resource utilization can be reduced.   * Increasement of DL RU is also observed, which depends on the UL subband configuration. * In ratio, reduction of UL performance is close to the increasement of DL performance. * Better self-interference isolation achieves lower UL resource utilization. |
| InterDigital | ***Observation 3.*** *Restricting DL subband transmissions on slots that correspond to UL slots in legacy TDD can improve uplink performance but negatively impacts downlink performance.*  ***Observation 4.*** *The static/fixed subband partitioning, e.g., [DUD] = [40 20 40] RB split all the time, results in worse performance for SBFD compared with legacy TDD in downlink, which is not reflecting a practical usefulness of SBFD.*  ***Proposal 3.*** *Evaluations on various downlink performance degradation aspects due to the SBFD operations compared with legacy TDD systems should also be an important part of the NR-Duplex study.*  ***Proposal 4.*** *To fairly reflect a practical usefulness of SBFD, the static/fixed subband partitioning assumption is not a proper assumption but is to be used as a baseline assumption for SBFD, where flexible/dynamic subband partitioning schemes should be further evaluated to overcome the degraded downlink performance for SBFD.* |
| NEC | ***Observation 2*** Inter-UE inter-subband CLI is not expected to be a serious concern for DL SINR and throughput performance  ***Observation 3*** Higher DL performance impact is expected due to co-subband inter-cell UE-UE CLI when different cells operate with different SBFD configurations |
| Apple | ***Observation 1***: For indoor scenario, UL Tx power has a big impact (positive or negative) on the UE-to-UE CLI.  ***Observation 2***: For most of indoor scenarios, the achievable gain in UL throughput is much less than the loss in DL throughput due to UE-to-UE CLI.  Proposal 2: Intra-subband CLI shall be avoided by the scheduler.  ***Observation 3:*** For indoor scenario with no CLI/SI at UE or gNB, UL throughput enhancement for cell-edge UEs is limited to 10% |

#### For dynamic/flexible TDD

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| **Company** | **Proposals** |
| Qualcomm | **FR1 Initial Performance Evaluation**  ***Observation 47***: Dynamic TDD based on SBHD deployment improves UL coverage as compared to static TDD due to more frequent UL Tx opportunities and UL blocking reduction.  ***Observation 48***: At least for FR1, Dynamic TDD based on SBHD deployment improves has no significant loss on DL performance as compared to static TDD for small packet transmission.  ***Observation 49:*** Dynamic TDD based SBHD improvs UL User Perceived Throughput by 48% as compared to static TDD by increasing UL duty cycle  **FR2 Initial Performance Evaluation**  ***Observation 50***: The downlink and uplink perceived throughput both have improved for dynamic TDD with traffic adaptive scheduling.  ***Observation 51:*** Dynamic TDD can provide up to 280% performance gain for UL UPT for file size such as 125 KB and dynamic TDD can provide up to 36% gain for DL UPT for file size such as 500 KB compared with legacy TDD.  ***Observation 52:*** To compare dynamic TDD with SBFD: 1) SBFD can save D to U switching overhead, which is not reflected in the current results; 2) SBFD can save common channel overhead by multiplexing common channel + the other direction traffic, e.g. SSB + UL traffic, RO + DL traffic, which is also not reflected by current simulation results. Those two factors will give more performance gain on SBFD compared with dynamic TDD.  ***Observation 53:*** The actual duplexing percentage has large variation across different cells. On average in this simulation setup, among all the slots, 14% of slots are FD slots, 26% of slots are dynamic DL-only slots, 20% of slots are dynamic UL-only slots, and 40% of slots are idle slots.  ***Observation 54:*** The low percentage of full duplex slots indicates that not all the performance gain in the full duplex simulation (shown in section 2.3.2) is achieved by the true simultaneous transmissions, but partial performance gain is achieved by dynamic TDD. Enabling dynamic TDD as a natural side-effect of FD is a significant source of the performance gain.  ***Observation 55***: The dynamic TDD slots shall have the same single panel antenna configuration as baseline legacy TDD. Actual dynamic TDD results will be provided next time for FR2. |
| MediaTek | ***Observation 13:*** In the examined HetNet scenario with misaligned TDD patterns, inter-gNB co-channel CLI causes about 20dB SINR degradation. CLI is much larger than CCI, and the strongest CLI component from one macro-cell aggressor dominates the CLI.  ***Observation 14:*** In the examined HetNet scenario with misaligned TDD patterns, inter-UE co-channel CLI is negligible when compared with co-channel interference from gNB (macro cells and small cells). |
| Intel | ***Observation 2:*** In absence of any coordination, due to gNB-to-gNB CLI the UL performance may substantially degrade in both FR-1 and FR-2 irrespective of the scenario when dynamic/flexible TDD operations is supported. |