**3GPP TSG RAN Meeting #97 RP-22xxxx**

**Electronic Meeting, September 12-16, 2022**

## Status Report to TSG

**Agenda item:** 9.2.6

|  |  |
| --- | --- |
| **WI / SI Name** | Study on evolution of NR duplex operation |
| included in this status report | Study Item: Yes | Core part: No | Performance part:No | Testing part:No |
| **Acronym** | FS\_NR\_duplex\_evo |
| **Unique ID** | 940082 |
| **TSG Tdoc of latest approved WI/SI description (if any)** | RP-221352 |
| **Target Completion Date****(indicate if changed)** | Study Item: 12/2023 | Core part: N/A | Performance part: N/A | Testing part: N/A |
| **Overall Completion level** | Study Item: 15% | Core part: N/A | Performance Part: N/A | Testing part: N/A |

Note: Overall completion level percentage numbers should use one of the colors below:

* xx%: Normal progress, no RAN plenary action needed
* xx%: Progress behind schedule, may need RAN plenary intervention. If so, SR should clearly define requested action
* xx%: Progress critically behind, RAN plenary shall intervene. SR should define requested action

**Source:**

|  |  |
| --- | --- |
| **Leading WG** | TSG RAN WG1 |
| **Rapporteur** | **Name** | Fei WANG |
| **Company** | CMCC |
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## 1 Work plan related evaluation

|  |  |
| --- | --- |
| **Do you want to modify the time budget for this WI/SI compared to what was endorsed at the last RAN meeting?** | No |

*If you answered No: Then please remove the Excel file from the zip file of this status report.*

*If you answered Yes: Then please fill out the attached Excel template to request a modification of the time budgets for your WI /SI. The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI. The basis are the endorsed time budgets of the last RAN meeting. Please highlight all changes of the values.
 One time unit (TU) corresponds to ~ 2 hours in the meeting.
 If this status report covers a WI with Core and Performance part, then please have one line for each in the attached Excel table.
 Note: If no Excel table is attached, then this means no time budget change.*

**Additional explanations/motivations for the time budget changes in the attached Excel table:**

## 2. Detailed progress in RAN WGs since last TSG meeting (for all involved WGs)

 NOTE: Agreements and Open issues impacted cross-TSG aspects shall be explicitly highlighted

## 2.1 RAN1

#### 2.1.1 Agreements

**Evaluation on NR duplex evolution**

**Agreement**

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 to submit results for both RU definitions
* FFS: RU definition for dynamic TDD evaluations

**Agreement**

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

* Baseline (UE clustering):
	+ 10 users per macro TRP
		- 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
		- 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%*
* Optional:
	+ 10 users per macro TRP, and all users are randomly and uniformly dropped within the macro cell
	+ At least for FR1: 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
		- FFS: FR2 details

**Agreement**

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

* 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]



**Agreement**

For latency related performance metric for FTP model 3 in SLS, option 1 is baseline, it is up to companies to report the latency with option 2.

* 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.
	+ (baseline) Option 1: 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.
	+ (optional) Option 2: 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.
* Note: HARQ re-transmission should be considered for latency evaluation.
* Unfinished/dropped FTP packets are not incorporated in the packet latency calculation.
	+ Unfinished/dropped Packet Rate is defined as the number of the unfinished packets for all users divided by the total number of generated packets for all users
		- To be reported as part of the system level simulation results

**Agreement**

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

* 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].
	+ Consider zero bit for dropped FTP packets.
	+ 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].
	+ Median-UPT of a user: defined as the 50% UPT among all FTP packets intended for this user.
	+ Average-UPT CDF: The CDF of the Average-UPTs for all users.
	+ Tail-UPT CDF: The CDF of the Tail-UPTs for all users.
	+ Median-UPT CDF: The CDF of the Median-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.
	+ Mean/5%/50%/95% Median-UPT: The mean/5%/50%/95% value of Median-UPTs for all users.

**Agreement**

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. Companies to report which option is used.* Option 1: Each UE is either assigned UL traffic or DL traffic.
	+ assume the same number of UEs for UL and DL, FFS the total number of UEs
	+ FFS how to handle the UE clustering case
* Option 2: Each UE is assigned both UL traffic and DL traffic.
 |
| FTP packet size | Both symmetric and asymmetric packet size for UL and DL can be considered. Companies to report which option is used.* Option 1: Symmetric packet size:
	+ 1Kbyte for DL/UL, 0.1Mbytes for DL/UL, 0.5Mbytes for DL/UL, 2Mbytes for DL/UL
* Option 2: Asymmetric packet size:
	+ 4Kbytes for DL and 1Kbyte for UL, 0.5Mbyte for DL and 0.125 Mbytes for UL
 |
| UL arrival rate for legacy TDD | * The UL arrival rate is selected to reach a target UL traffic load (RU).
* UL Traffic load: low UL RU ([<10%]), medium UL RU ([20%-30%]), and high UL RU ([~50%]).
* Note: Type-2 RU definition (calculated per link direction) is used
 | * The UL arrival rate#1 of Macro cell and UL arrival rate#2 of Micro cell are selected to reach target UL traffic load (RU)#1 of Macro cell and target UL traffic load (RU)#2 of Micro cell, respectively
* UL Traffic load: low UL RU ([<10%]), medium UL RU ([20%-30%]), and high UL RU ([~50%]).
* Note: Type-2 RU definition (calculated per link direction) is used
 |
| 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 ([<10%]), medium DL RU ([20%-30%]), and high DL RU ([~50%]).
* 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 ([<10%]), medium DL RU ([20%-30%]), and high DL RU ([~50%]).
* Note: Type-2 RU definition (calculated per link direction) is used
 |
| Arrival rate for SBFD | The UL and DL FTP packet arrival rate for SBFD are the same as legacy TDD. |

**Working assumption:**

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

|  |  |  |
| --- | --- | --- |
|  | **Dense urban, Urban macro** | **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)
 |
| 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
 |

**Agreement**

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

|  |  |  |
| --- | --- | --- |
|  | **FR1** | **FR2-1** |
| System bandwidth | 100MHz | 100MHz |
| Numerology | 14 OFDM symbol slotSCS = 30kHz | 14 OFDM symbol slotSCS = 120kHz |
| 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 | Companies to report the option used.Option 1: IdealOption 2: Realistic [refer to TR 38.802 Table A.2.1-1] |
| UE processing capability | UE processing capability 1 as baseline | UE processing capability 1 as baseline |
| 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 |

**Agreement**

Update the previous agreement as below:

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

* Baseline: (UE clustering at least for FR1)
	+ *M* users per macro TRP
		- 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 in the macro geographical area outside the clusters
		- Note: UEs dropped within the UE cluster(s) are indoor with 3km/h; UEs dropped outside the UE cluster(s) are outdoor in car with 30km/h
		- UE outdoor/indoor proportion: 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
			* Outdoor UEs: 1.5 m;
			* FFS: Indoor UEs height
		- Y%=80%
		- FFS the values of *M*, X*,* Dmacro-to-cluster, Dinter-cluster*,* R
* Optional:
	+ 10 users per macro TRP (per direction), and all users are randomly and uniformly dropped within the macro cell
	+ At least for FR1: 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
		- Outdoor UEs: 1.5 m;
		- Indoor UEs: 3(nfl – 1) + 1.5; nfl ~ uniform(1, Nfl) where Nfl ~ uniform(4,8) [refer to TR 36.873 Table 6-1]
		- FFS: FR2 details

**Agreement**

For LOS probability of gNB-gNB channel,

* For Macro-gNB-to-Macro-gNB case
	+ 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.
		- X = 0.75
* For other cases, reuse gNB-to-UE LOS probability equation in TR 38.901.

**Agreement**

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, all users are randomly and uniformly dropped around Micro TRP center with the radius of R (R = [28.9m]).

**Agreement**

For UE distribution of Dense Urban with 2-layer, reuse the modeling in TR38.802 as much as possible.

* For FTP traffic model 3: 2/3 users randomly and uniformly dropped around micro TRP centers with 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.
* UE outdoor/indoor proportion: 20% outdoor in cars: 30km/h; 80% indoor in houses: 3km/h
	+ Outdoor UEs: 1.5 m;
	+ Indoor UEs: 3(nfl – 1) + 1.5; nfl ~ uniform(1, Nfl) where Nfl ~ uniform(4,8)

**Agreement**

For evaluation of SBFD and dynamic/flexible TDD, the following BS transmit power for legacy TDD are considered. These values are for the single operator case.

|  |  |  |
| --- | --- | --- |
|  | **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]
 | N.A. |
| **Dense Urban Macro layer** | * Option 1: [53] dBm for 100MHz
* Option 3: [44] dBm for 100MHz [refer to TR 38.802 Table A.2.1-1]
 | * Option 1: [43] dBm for 200MHz [refer to TR 38.828 Table 5.2.2.4-1]
 |
| **Dense Urban Micro layer** | * Option 3: [40] dBm for 100MHz [refer to TR 38.802 Table A.2.1-1]
 | * 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: [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 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]
 |

**Agreement**

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 (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)
	+ Companies can also consider evaluation with other realistic BS antenna radiation pattern

**Agreement**

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)

Working Assumption

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | **Indoor office** | **Urban macro / Dense Urban Macro layer** | **Dense Urban with 2-layer** |
| **Layout** | Single layerIndoor floor: (12BSs per 120m x 50m)  | Single layerMacro layer: * Baseline: Hexagonal grid with 7 macro sites and 3 sectors per site with wrap around
* Optional: Hexagonal grid with 19 macro sites and 3 sectors per site with wrap around.
 | Two layerMacro layer:* Baseline: Hexagonal grid with 7 macro sites and 3 sectors per site with wrap around
* Optional: Hexagonal grid with 19 macro sites and 3 sectors per site with wrap around.

Micro layer: According to previous agreement* Baseline: 3 Micro BSs per Macro BS
* Optional: 6, or 9 Micro BSs per Macro BS
 |
| **Inter-BS (2D) distance** | 20m [TR 38.802 Table A.2.1-11] | 500m for Urban Macro [TR 38.802 Table A.2.1-11]200m for Dense Urban Macro layer [TR 38.802 Table A.2.1-1] | **Macro-to-macro:** 200m**Minimum Macro-to-micro-center distance:** 105m **Minimum Micro-center-to-micro-center distance:** 57.9m |
| **Minimum BS-UE (2D) distance** | 0m [TR 38.802 Table A.2.1-11] | 35m [TR 38.802 Table A.2.1-11] | **Macro-to-UE**: 35m **Micro-to-UE**: 10m [TR 38.802 Table A.2.1-11] |
| **Minimum UE-UE (2D) distance** | FFS | FFS :3m [TR 38.802 Table A.2.1-11] | FFS: 3m [TR 38.802 Table A.2.1-11] |
| **BS antenna height** | 3 m [TR 38.802 Table A.2.1-1] | 25 m [TR 38.802 Table A.2.1-1] | 25m for macro cells and 10m for micro cells [TR 38.802 Table A.2.1-1] |

**Conclusion**

* For SLS of NR duplex evolution, Rural scenario is not considered in Rel-18.
* For NR duplex evolution evaluation, FR2-2 is not considered in Rel-18.

Agreement

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.

Agreement

RAN1 strives to agree on system level simulation parameters for SBFD deployment case 4 by RAN1#110bis-e with specific focus on different power levels and load levels between two operators in adjacent carriers.

Agreement

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

* Legacy parameters $\left(M,N,P,M\_{g},N\_{g}\right)$, $\left(d\_{H},d\_{V}\right)$ and $\left(d\_{g,H},d\_{g,V}\right)$ 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
	+ $M\_{g}$: Number of panels in a column within a panel group.
	+ $N\_{g}$: Number of panels in a row within a panel group.
	+ $d\_{g,H}$: Antenna panel spacing in horizontal direction within a panel group.
	+ $d\_{g,V}$: Antenna panel spacing in vertical direction within a panel group.
* Companies are to report the separation of the two panel groups. Introduce new parameters $\left(d\_{a,H},d\_{a,V}\right)$ as illustrated in the following figure.
	+ $d\_{a,H}$: Panel group spacing in the horizontal direction. Typically, $d\_{a,H}$ = 0.
	+ $d\_{a,V}$: Panel group spacing in the vertical direction.



Agreement

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 $\left(M,N,P,M\_{g},N\_{g};M\_{p},N\_{p}\right)$. The total number of TxRUs is $K=PM\_{p}N\_{p}M\_{g}N\_{g}$, and the total number of antenna elements is $L=PMNM\_{g}N\_{g}$.



* 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 $\left(M,N,P,M\_{g}/2,N\_{g}\right)$. The total number of TXRUs is $K=PM\_{p}N\_{p}M\_{g}N\_{g}$ (same as legacy TDD), and the total number of antenna elements is $L=PMNM\_{g}N\_{g}$(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 $\left(M,N,P,M\_{g},N\_{g}\right)$. The total number of TXRUs is $K=PM\_{p}N\_{p}M\_{g}N\_{g}$ (same as legacy TDD), and the total number of antenna elements is $2L=2PMNM\_{g}N\_{g}$(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 $\left(M,N,P,M\_{g}/2,N\_{g}\right)$. The total number of TXRUs is $K/2=PM\_{p}N\_{p}M\_{g}N\_{g}/2$ (half of that for legacy TDD), and the total number of antenna elements is $L=PMNM\_{g}N\_{g}$(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.



Working Assumption

For UE-UE channel model, reuse the UE-UE channel model for flexible duplex evaluation in TR 38.802 for both FR1 and FR2 as baseline, and other models are not precluded.

**UE-UE channel model**

|  |  |  |
| --- | --- | --- |
|  | **Dense urban, Urban macro** | **Indoor hotspot** |
| Large-scale channel parameters | FR1:* Option 1: UE-to-UE: A.2.1.2 in TR36.843(\*), penetration loss between UEs follows Table A.2.1-13 in TR38.802
* Option 2: UE-to-UE: UMi-Street canyon in TR 38.901 (hBS =1.5m ~ 22.5m), penetration loss between UEs follows Table A.2.1-13 in TR38.802

FR2-1:* UE-to-UE: UMi-Street canyon in TR 38.901 (hBS =1.5m ~ 22.5m), penetration loss between UEs follows Table A.2.1-12 in TR38.802
 | FR1:* Option1 : UE-to-UE: A.2.1.2 in TR36.843 (\*)
* Option 2: UE-to-UE: InH-Office in TR 38.901 (hBS =1.5m)

FR2-1:* UE-to-UE: InH-Office in TR 38.901 (hBS =1.5m)
 |
| Fast fading parameters | FR1:* Option 1: 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.
* Optioin 2: UE-to-UE: UMi-Street canyon in TR 38.901; 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:* Option 1: UE-to-UE: A.2.1.2 in TR36.843 (ITU InH), ASD statistics updated to be the same as ASA.
* Option2: 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

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
 |
| (\*): 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 A.2.1-13 in TR38.802. |

**Agreement**

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.



**Agreement**

For evaluation of SBFD operation, it is up to companies to 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 | $\left(M,N,P,M\_{g},N\_{g};M\_{p},N\_{p}\right) $= (4,4,2,1,1; 4,4) $\left(d\_{H},d\_{V}\right)$= (0.5, 0.5)λ, +45°/-45° polarization | * SBFD antenna configuration option-1 (Method 1)
	+ Two panel groups
	+ For each panel group: $\left(M,N,P,M\_{g},N\_{g}\right)$= (2,4,2,1,1).
	+ Number of TxRUs: same as legacy TDD
	+ $\left(d\_{H},d\_{V}\right)$= (0.5, 0.5)λ, +45°/-45° polarization, (da,H,da,V) = (0, 4)λ
 |
| FR2-1 | $\left(M,N,P,M\_{g},N\_{g};M\_{p},N\_{p}\right)$=(16,8,2,1,1; 1,1)$\left(d\_{H},d\_{V}\right)$= (0.5, 0.5)λ, +45°/-45° polarization | * SBFD antenna configuration option-1 (Method 1)
	+ Two panel groups
	+ For each panel group: $\left(M,N,P,M\_{g},N\_{g}\right)$= (8,8,2,1,1).
	+ Number of TxRUs: same as legacy TDD
	+ $\left(d\_{H},d\_{V}\right)$= (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 | $\left(M,N,P,M\_{g},N\_{g};M\_{p},N\_{p}\right)$=(8,8,2,1,1;2,8) $\left(d\_{H},d\_{V}\right)$ = (0.5, 0.8)λ, +45°/-45° polarization | * SBFD antenna configuration option-1 (Method 1)
	+ Two panel groups
	+ For each panel group: $\left(M,N,P,M\_{g},N\_{g}\right)$= (4,8,2,1,1).
	+ Number of TxRUs: same as legacy TDD
	+ $\left(d\_{H},d\_{V}\right)$ = (0.5, 0.8)λ, +45°/-45° polarization, (da,H,da,V) = (0, 4)λ
 |
| FR2-1 | $\left(M,N,P,M\_{g},N\_{g};M\_{p},N\_{p}\right)$=(4,16,2,2,2; 1,1)$\left(d\_{H},d\_{V}\right)$= (0.5, 0.5)λ, +45°/-45° polarization | * SBFD antenna configuration option-1 (Method 1)
	+ Two panel groups
	+ For each panel group: $\left(M,N,P,M\_{g},N\_{g}\right)$= (4,8,2,2,2).
	+ Number of TxRUs: same as legacy TDD
	+ $\left(d\_{H},d\_{V}\right)$ = (0.5, 0.5)λ, +45°/-45° polarization, (da,H,da,V) = (0, 30)λ
 |

**Subband non-overlapping full duplex**

**Agreement**

Study the following alternatives with Alt 4 prioritized, for SBFD operation at least for RRC\_CONNECTED state.

* SBFD operation Alt 1:
	+ Time and frequency locations of subbands for SBFD operation are not known to UEs.
	+ UE behaviors follow existing specifications without introducing new UE behaviors for SBFD operation at gNB side.
* SBFD operation Alt 2:
	+ Time and frequency locations of subbands for SBFD operation are not known to UEs.
	+ UE behaviors for non-SBFD aware UEs follow existing specifications.
	+ From RAN1 perspective, new UE behaviors can be introduced for SBFD aware UEs
* SBFD operation Alt 3:
	+ Only time location of subbands for SBFD operation is known to SBFD aware UEs.
	+ UE behaviors for non-SBFD aware UEs follow existing specifications.
	+ From RAN1 perspective, new UE behaviors can be introduced for SBFD aware UEs based on the time location of subbands for SBFD operation
* SBFD operation Alt 4:
	+ Both time and frequency locations of subbands for SBFD operation are known to SBFD aware UEs.
	+ UE behaviors for non-SBFD aware UEs follow existing specifications.
	+ From RAN1 perspective, new UE behaviors can be introduced for SBFD aware UEs based on the time and frequency locations of subbands for SBFD operation.

UE capability discussion is held in work item phase.

**Agreement**

For indication of subband locations for SBFD operation, study semi-static configuration of subband time and frequency location as baseline.

**Agreement**

For semi-static configuration of subband location, consider same subband frequency resources across different SBFD symbols as baseline.

**Working Assumption**

For SBFD operation within a TDD carrier, study SBFD scheme within a single configured DL and UL BWP pair with aligned center frequencies as baseline.

* FFS feasibility and potential benefit of SBFD scheme within a single configured DL and UL BWP pair with unaligned center frequencies
* FFS feasibility and potential benefit of SBFD scheme with more than one configured DL and UL BWP pair with aligned/unaligned center frequencies for a DL and UL BWP pair

**Agreement:**

For SBFD operation Alt 4, for an SBFD aware UE configured with an UL subband in an SBFD symbol, study the following options:

* + Option 1: The SBFD aware UE does not expect to be scheduled with UL transmission outside the UL subband or to be scheduled with DL reception within the UL subband in the SBFD symbol
	+ Option 2: The SBFD aware UE does not expect to be scheduled with UL transmission outside the UL subband and may be scheduled with DL reception within the UL subband in the SBFD symbol
	+ Option 3: The SBFD aware UE does not expect to be scheduled with DL reception within the UL subband and may be scheduled with UL transmission outside the UL subband in the SBFD symbol
	+ Option 4: The SBFD aware UE may be scheduled with UL transmission outside the UL subband or DL reception within the UL subband in the SBFD symbol

**Agreement:**

Study the feasibility and potential benefit of UE-to-UE co-channel CLI measurement and reporting, which can be specific for SBFD, at least includes:

* Measurement resource/reporting configuration
* Measurement/reporting details (including UE processing delay)
* Relevant information exchange (between gNBs) if needed
* Usage of measurement at gNB

Note: other enhancement(s) for gNB-to-gNB and UE-to-UE CLI handling specific for SBFD are not precluded.

**Potential enhancements on dynamic/flexible TDD**

**Agreement**

Study the feasibility and potential benefits of gNB-to-gNB co-channel CLI measurement for gNB-to-gNB CLI handling which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic/flexible TDD, at least includes:

* Measurement resource configuration
* Measurement details
* Relevant information exchange
* Usage of measurement

**Agreement**

Study the feasibility and potential benefit of UE-to-UE co-channel CLI measurement and reporting, which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic/flexible TDD, at least includes:

* Measurement resource/reporting configuration
* Measurement/reporting details (including UE processing delay)
* Relevant information exchange (between gNBs) if needed
* Usage of measurement at gNB

**Agreement**

Study the feasibility and potential benefits of coordinated scheduling for time/frequency resources between gNBs for gNB-to-gNB co-channel CLI handling which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic/flexible TDD, the study at least includes:

* Details of coordinated scheduling for time/frequency resources
* Relevant information exchange

**Agreement**

Study the feasibility and potential benefits of spatial domain coordination method for gNB-to-gNB co-channel CLI handling which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic/flexible TDD, the study at least includes:

* Details for spatial domain coordination
* Relevant information exchange

Note1: Study can include method for FR1 and FR2

**Agreement**

Study the feasibility and potential benefits of coordinated scheduling for time/frequency resources between gNBs (if needed) for UE-to-UE co-channel CLI handling which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic/flexible TDD, at least includes:

* Details of coordinated scheduling for time/frequency resources
* Relevant information exchange (if needed)

**Agreement**

Study the feasibility and potential benefit of UE-to-UE co-channel CLI handling based on spatial domain coordination method which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic /flexible TDD, at least includes:

* Details for spatial domain coordination by gNB
* Relevant information exchange (if needed)

Note1: Study can include method for FR1 and FR2

#### 2.1.2 Remaining Open issues

About 20%~25% of the items of RAN1 objectives have been accomplished. All RAN1 objectives require further work.

## 2.3 RAN2

#### 2.3.1 Agreements

#### 2.3.2 Remaining Open issues

## 2.3 RAN3

#### 2.3.1 Agreements

#### 2.3.2 Remaining Open issues

## 2.4 RAN4

#### 2.4.1 Agreements

**Feasibility study from RF perspective** (as approved in R4-2214377)

**Topic 1: RAN4 feasibility study and RF requirement impact for SBFD operation**

Agreement from gNB perspective

* Proposal 1: If found feasible, SBFD operation requires new/enhanced implementation for gNB capable of SBFD and cannot be software upgraded to existing BS
* Proposal 2: No impact on requirement applied to existing gNB or gNB not capable of SBFD operation.
* Open issues will be further discussed in RAN4 for feasibility and RF requirement impact

Agreement from UE perspective:

* Using existing UE RF requirements to estimate UE performance and if needed extrapolating them for system level studies

Agreement on Criteria on gNB UL receiver sensitivity degradation due to self-interference:

* Taking 1dB sensitivity degradation due to self-interference of DL transmission as starting point for system level evaluation and feasibility study
	+ Other values lower than 1dB e.g. 0.1dB/0.8dB not precluded pending on the feasibility study
	+ Final values used in co-existence evaluation shall be aligned with feasibility analysis conclusion.

**Topic 2: Self-interference modelling for gNB capable of SBFD operation according to RAN1 LS**

Agreement on granularity in frequency domain and question on frequency flat model possibility (Question 1-1/3/5):

* Proposal: RSI can be modelled as (almost) frequency flat at least could be scaled to subband level with FFS on below aspects
	+ FFS on guardband assumption between subband for SBFD
	+ FFS on necessity/feasibility on RB level scaling

Agreement on RSI dependency on Blocking and AGC（Question 1-4）:

* Proposal 1: The in-band blocking is suggested to applied as starting point to ensure the receiver of UL sub-band is not blocked due to DL sub-band transmission
	+ Besides blocking, LNA and dynamic range can be FFS for receiver side
* Proposal 2: AGC may be applied to adjust the receiver gain to avoid ADC saturation if spatial isolation and analog IC, if found feasible, don’t provide enough reduction to self-interference. This may result in cost of an impact on sensitivity and potentially reduced coverage. However, it seems infeasible to model this in SLS.

Note: above proposal will not preclude other study regarding this issue. The size of any impact of coverage associated with AGC should in particular be elaborated.

Agreement on dependency on gNB antenna and beam related (Question 1-5):

* Proposal 1: gNB antenna architecture has impact on RSI model as to achieve high spatial isolation, separate antenna panels between TX and RX chain are requested
* Proposal 2: TX/RX beam pair can further contribute to RSI pending on implementation.
* Proposal 3: the RSI will have dependency at least on the listed factors in RAN1 LS, but further details will need to be studied in RAN4.

**Topic 3: co-channel inter-subband gNB-gNB CLI modelling according to RAN1 LS**

Agreement on feasibility and how to model co-site inter-sector gNB-gNB CLI modelling:

* Similar modelling as for self-interference (RSI) can be applied but may with different parameters especially on antenna isolation
	+ FFS on possibility to apply digital IC for this case

Agreement on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity:

* Proposal: Same Transmitter leakage and receiver impairment model as used for investigating gNB self-interference, but antenna isolation is replaced with inter-site isolation.
	+ TX leakage candidate: gNB ACLR
	+ Receiver impairment candidate: gNB ACS
	+ RAN4 will further study the possibility of improved performance/requirements compared to existing referred requirements list above.

**Topic 4: co-channel inter-subband UE-UE CLI model according to RAN1 LS**

Candidate considerations for UE-UE CLI model:

* TX model can refer to existing UE requirement in TS38.101-1 and TS38.101-2
	+ In band emission as starting point
	+ FFS is not precluded for other candidates such as ACLR
* RX model can refer to existing UE requirement in TS38.101-1 and TS38.101-2
	+ Maximum input power as threshold based on above specification
	+ FFS is not precluded for other candidates such as ACS, ICI, and estimated RX model based on legacy UE.

**Topic 5: adjacent-channel gNB-gNB CLI model according to RAN1 LS**

Agreement on feasibility and how to model co-site gNB-gNB CLI modelling:

* Proposal : as no path loss model applicable this modelling could be different compared with inter-site gNB-gNB CLI modelling with below alternatives:
	+ Alternative 1: ACLR and ACS based with potential other solution from SBFD capable gNB to cancel co-cite adjacent channel interference(i.e. ACLR from the SBFD gNB towards the victim or ACS impact from the aggressor towards the SBFD gNB)
		- A non-SBFD aggressor or victim in the adjacent channel should be assumed to have ACLR or ACS according to the RAN4 specifications
		- Note: RAN4 will further study the possibility of improved performance/requirements compared to existing referred requirements list above.
	+ Alternative 2: similar modelling as for self-interference(RSI) can be applied but may with different parameters especially on antenna isolation and required overall isolation if both gNBs with SBFD capability
		- And digital IC is not feasible if gNBs belong to different operators for this case

Agreement on feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity:

* Proposal: to agree with gNB ACLR based model on TX and gNB ACS requirements based model on RX
	+ Path loss should be addressed due to distance between gNBs.
	+ FFS on separate calculation from ACLR and ACS perspective to address potential different antenna gain for wanted signal and unwanted signal (e.g.different antenna modelling for wanted signal and unwanted signal).
	+ Note: RAN4 will further study the possibility of improved performance/requirements compared to existing referred requirements list above.

**Topic 6: adjacent-channel UE-UE CLI model according to RAN1 LS**

Agreement on feasibility and how to model UE-UE CLI modelling considering unwanted emission and receiver selectivity:

* Model as starting point: UE ACLR based model on TX and UE ACS based model on RX which is the same ACIR model as Rel-16 CLI study.
* FFS on below model
	+ UE ACLR model with 2step size(FR1 example: ACLR1/2=28/33dB) on TX
	+ UE ACS based model on RX if blocker is smaller than maximum input level of UE, and additional SNR degradation at the victim receiver due to receiver gain backoff
* FFS on how the per-sub-band/RB aspect is characterised. Other aspect is also not precluded

Reply LS according to RAN1 request on interference modelling of SBFD operation is approved in R4-2214377 based on above agreement.

**Adjacent channel study** (as approved in R4-2214378)

Agreement on necessity on SLS in RAN4

* Adjacent channel co-existence study in RAN4 for SBFD is needed.
* The SLS is needed for RAN4 co-ex study because the interference scenario is different from the Rel-16 CLI study and the study target is different from RAN1.
* Purpose required:
	+ - The feasibility and supporting deployment scenarios with SBFD operation should be studied from RAN4 adjacent channel co-existence perspective.
		- Investigate and determine ACIR values (ACLR/ACS requirements) for gNB with the capability of SBFD operation.
* SBFD interference scenarios is different compared to CLI deployment:
	+ - The CLI study does not have full-duplex operation. In CLI study, only one of the serving BS or associate UE(s) can transmit in each simulated cells. But in SBFD simulation, both BS and UE are transmitting in each cell.
		- The SBFD assumptions, as antennas, subband channel arrangement, number of associate UEs and all those in current and future discussions, are different from the assumptions of CLI simulations.
	+ The co-existence work in RAN4 does not intend to cover the objective of RAN1 which, as specified in SID, is to study performance of the identified schemes as well as impact on legacy operations assuming their co-existence in co-channel and adjacent channels.
	+ The interference scenarios and assumptions for conducting co-ex study would take into account the Rel-16 CLI results.
	+ FFS if RAN4 co-ex study needs to take into account the RAN1-devised solutions.
	+ FFS how RAN4 study would be used for potential enhancement to dynamic TDD
		- Candidate option: In case there are findings of SBFD adjacent channel co-existence study that are not aligned with findings from the Rel-16 CLI study, RAN4 will check if those findings are also applicable for dynamic TDD operation which does not suffer from self-interference.

Agreement on scenarios for adjacent channel co-existence study in RAN4

* For FR1 SBFD scenarios for co-ex study:
	+ Consider Urban Macro as baseline scenarios with high priority;
	+ Consider Indoor scenario as second priority and not to preclude other scenarios.
* For FR2 SBFD scenarios for co-ex study:
	+ Consider Urban Macro as baseline scenario with high priority;
	+ Consider Urban Micro, Indoor scenarios as second priority and not preclude other scenarios.
* For scenarios, including aggressor, victim and aggressor baseline, of co-ex study:
	+ For NR TDD DL as victim, assumes NR TDD DL in adjacent channel as aggressor baseline; assumes SBFD in adjacent channel as aggressor.
	+ For NR TDD UL as victim, assumes NR TDD UL in adjacent channel as aggressor baseline; assumes SBFD in adjacent channel as aggressor. Consider the cases, where NR TDD UL as victim, with lower priority.
	+ For SBFD as victim, assumes TDD DL as aggressor with high priority while consider the TDD UL as aggressor and SBFD as aggressor cases with low priority. The aggressor baseline, for SBFD as victim, is FFS with following candidate options:
		- Option 1: No system in adjacent channel;
		- Option 2: SBFD in adjacent channel.

Agreements can be summarized into the tables below.

Table 2.4.1-1: Scenarios for SBFD co-ex study

|  |  |  |  |
| --- | --- | --- | --- |
| FR | ScenarioNo. | Deployment Scenario1(Aggressor -> Victim) | Priority |
| FR1(4GHz) | 1 | Urban Macro -> Urban Macro | High |
| 2 | Indoor -> Indoor | Low |
| FR2(30GHz) | 3 | Urban Macro -> Urban Macro | High |
| 4 | Urban Micro -> Urban Micro | Low |
| 5 | Indoor -> Indoor | Low |
| Note 1: The Urban Macro is agreed as baseline scenario for SBFD co-ex study with high priority in RAN4#104-e, while it does not preclude other scenarios. |

Table 2.4.1-2: Victim, aggressor and aggressor baseline for SBFD co-ex study

|  |  |  |  |
| --- | --- | --- | --- |
| Victim | Aggressor | Aggressor baseline | Priority |
| NR TDD DL | SBFD | NR TDD DL | High priority |
| NR TDD UL | SBFD | NR TDD UL | Low priority |
| SBFD | NR TDD DL | FFS | High priority |
| NR TDD UL | Low priority |
| SBFD | Low priority |

**Simulation assumption for adjacent co-existence study** (as approved in R4-2214379)

Agreement on Frequencies for co-ex study

* FR1: 4GHz as exemplary frequency, FR2: 30GHz as exemplary frequency.
* Not consider FR 2-2.

Agreement on SBFD sub-band configurations in co-ex study

* To consider both {DUD} and {DU} configurations in this stage, while not preclude to reduce to one configuration if two configurations are equivalent for study after agreed on other assumptions.

Agreement on Inter-site distance (ISD)

* FR1 UMa with 500m ISD, FR2 UMa with 200m ISD.

Agreement on Path-loss model: Take option 1 as starting point.

* Option 1: Re-use TR 38.828 as starting point

Agreement on Grid shift considerations

* Further study following candidate options for grid shift in SLS and analysis.
* Option 1: 100%
* Option 2: 0%
* Option 3: 10%
* Option 4: TBA

Agreement on UE distribution in macro scenario

* For Indoor/Outdoor UE ratio: Further study with following candidate options:
* Option 1-1: Re-use TR 38.828, which means FR1 Macro-to-Macro uses 20% indoor and 80% outdoor; FR2 Macro-to-Macro uses 0% indoor, Micro-to-Micro uses 80% indoor and 20% outdoor;
* Option 1-2: For Macro-to-Macro cases of both FR1 and FR2, assume 80% indoor and 20% outdoor ratio.
* For Indoor/Outdoor UE ratio:Further study with following candidate options:
* Option 2-1: Evenly random dropping in service area;
* Option 2-2: Consider clusters in UE dropping.
	+ - Step 1: Randomly drop a cluster within a macro cell geographical area considering the minimum distance between macro TRP to cluster centre, e.g., 100m , where the size of each cluster is 120 x 50 (m);
		- Step 2: 80% UEs are randomly and uniformly dropped within the cluster, and 20% UEs are randomly and uniformly dropped outside the cluster.
* For Indoor/Outdoor UE ratio: user numbers per transmission reception point should equal to the number of sub-bands, i.e. 2 UEs for {DU} subband config, 3 UEs for {DUD} config.

Agreement on Noise figures

* For Macro case, Re-use TR 38.828 assumptions -- FR1 BS: 5dB, UE: 9dB; FR2 BS: 10dB, UE: 10dB.

Agreement on BS antenna and TRP considerations: Further study with following options:

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

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

* Option 2: Use extended AAS model defined in TR 38.803, Table 5.2.3.2.4-2 as the sub-array is essential to be able to provide TX/RX isolation required for SBFD. For FR1 parameters in TR 38.803, Table 5.2.3.2.4-3 is proposed as starting point. Parameters for FR2 is proposed as Table 4 in R4-2212620. Detailed parameters are copied in annex 1
* Option 3: SBFD needs to be able to function with realistic power levels per carrier in today’s deployments. E.g. 55 dBm as second power level to be studied.

Agreement on UE antenna and Tx power

* For FR1: Re-use TR 38.828 assumptions. i.e. FR1 max Tx 23dBm, min Tx -40 dBm with 0dBi omni directional antenna.
* For FR2: Further study with following candidate options:
	+ Option 1: Re-use TR 38.828 assumptions. i.e. FR2 max Tx 13.4dBm (peak eirp 22.4dBm), min Tx -40dBm, with antenna configuration in the table of annex 2
	+ Option 2: FR2 max Tx 23dBm (peak eirp 43dBm) with (M, N, P)=(1, 4, 2), 2 panels antennas and element gain as 1.5 dBi

Agreement on BS mechanical down-tilt angles: Further study with following candidate options

* Option 1: Use 6 degrees for Macro BS for FR1 and FR2 as provided in TR 38.803, and 90-deg (point to ground) for indoor.
* Option 2: Mechanical tilt should be determined together with array parameters as a package per considered deployment scenario.

Agreement on Uplink power control model

* Use the following as the general uplink power control model for SBFD co-existence study.

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

Agreement on BS ACLR/ACS considerations

* Re-use TR 38.828 assumptions -- ACLR/ACS for FR1 BS: 45/46 dBc, FR2 BS: 28/23.5 dBc.

Agreement on SBFD self-interference consideration in SLS

* Proposed to use {N = noise floor + XdB} for the SBFD system to simulate the self-interference impact as a simplified method to evaluate its SINR/throughput.
* For the value of X:Taking 1dB sensitivity degradation due to self-interference of DL transmission as starting point for system level evaluation and feasibility study
	+ Other values lower than 1dB e.g. 0.1dB/0.8dB not precluded pending on the feasibility study
	+ Final values used in co-existence evaluation shall be aligned with feasibility analysis conclusion.

Agreement on Co-ex study steps

* Agree on Option 1 with the noise floor of SBFD as {N = noise floor + XdB}
* Option 1: Propose to adopt the following steps, modified from TR 38.828 and other general legacy RAN4 coex study report, as the simulation steps for SBFD coex study.
* For the value of X: Taking 1dB sensitivity degradation due to self-interference of DL transmission as starting point for system level evaluation and feasibility study
* Other values lower than 1dB e.g. 0.1dB/0.8dB not precluded pending on the feasibility study
* Final values used in co-existence evaluation shall be aligned with feasibility analysis conclusion.

|  |
| --- |
| 1. Aggressor and victim network are generated.- UEs are distributed according to the agreements on UE distribution.2. UE associations: UEs are associated to base station based on coupling loss.- Associations are made assuming a single element at both UE and BS.3. Once association is done, round robin scheduling is used. BF weights are adjusted to point to the LOS direction between BS-UE. This is done for both victim and aggressor networks.4. When legacy TDD system is victim, follow steps 4a:4a. Throughput is computed considering ACI from another static TDD system, with the same TDD UL/DL configuration, as baseline aggressor:- , where  is the inter-cell interference and  is the adjacent channel interference from the baseline aggressor.When SBFD system is victim, follow steps 4b:4b. Throughput is computed in the victim system without considering ACI as below:- , where  is the inter-cell interference.5. Throughput is computed considering ACI below:- , where  is the adjacent channel interference. . Throughput shall be reported separately for aligned TDD slots (i.e. legacy slots) and SBFD slots. |

Agreement on Evaluation metrics

* It is proposed to follow the TR 38.828’s evaluation criteria to check the 50% and 5% throughput loss compared to the baseline scenario defined.
* FFS for traffic model;

Agreement on Other assumptions

* Take option 1 as basis for those SLS assumptions that were not discussed.
* Option 1: Propose to adopt the system characteristics, deployment parameters and other assumptions from TR 38.828 as the starting point for SBFD co-ex study. But the assumptions should be updated accordingly to fulfill the SBFD co-ex purpose.

Work plan on RAN4 perspective approved in R4-2214777.

#### 2.4.2 Remaining Open issues

10% of the items defined in the RAN4 SID objectives have been accomplished. All objectives from SID on evolution of NR duplex operation require further work.

## 2.5 RAN5

#### 2.5.1 Agreements

#### 2.5.2 Remaining Open issues

#### 2.5.3 Remaining Open issues with cross-WG dependencies

## 2.6 RAN6

#### 2.6.1 Agreements

#### 2.6.2 Remaining Open issues

## 3. Detailed progress in SA/CT WGs since last TSG meeting (for all involved WGs)

NOTE: This section only needs to be filled in for WI/SIs where there is a corresponding relevant WI/SI in SA/CT.

## 3.1 SAx/CTs

#### 3.1.1 Agreements with cross-TSG impacts

#### 3.1.2 Remaining Open issues with cross-TSG impacts

NOTE: This section should also flag any critical dependencies that need TSG attention.

## 4. References

NOTE: This can be e.g. a list of all related Tdocs in the affected WGs since last TSG, references to LSs, produced TRs/TSs, the work/study item description or status reports of previous TSGs.

RAN1#110 contributions:

1. R1-2206908 Updated work plan on Rel-18 evolution of NR duplex operation SI CMCC, Samsung
2. R1-2205810 On deployment scenarios and evaluation methodology of NR full duplex Dell Technologies
3. R1-2205814 Evaluation methodolgy for NR duplex evolution Kumu Networks
4. R1-2205842 Proposing New Energy Consumption Metric for SBFD VODAFONE Group Plc
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. R1-2206909 Summary#1 of email discussion on evaluation of NR duplex evolution Moderator (CMCC)
20. R1-2206910 Discussion on evaluation on NR duplex evolution CMCC
21. R1-2206983 Deployment scenarios and evaluation methodology for NR duplex evolution MediaTek Inc.
22. R1-2207230 On Deployment scenarios and evaluation Methodology for NR duplex evolution Qualcomm Incorporated
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24. R1-2207334 Initial evaluation on NR duplex evolution Apple
25. R1-2207363 Study on Evaluation for NR duplex evolution LG Electronics
26. R1-2207405 Discussion on evaluation on NR duplex evolution NTT DOCOMO, INC.
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31. R1-2207888 Summary#3 on evaluation on NR duplex evolution Moderator (CMCC)
32. R1-2208030 Summary#4 on evaluation on NR duplex evolution Moderator (CMCC)
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34. R1-2208270 Summary#6 on evaluation on NR duplex evolution Moderator (CMCC)
35. R1-2208271 Final summary on evaluation on NR duplex evolution Moderator (CMCC)
36. R1-2205812 Discussion on NR sub-band full duplex Dell Technologies
37. R1-2205815 RF cancellation techniques for subband non-overlapping full duplex Kumu Networks
38. R1-2205834 Discussion on Subband non-overlapping Full Duplex TCL Communication Ltd.
39. R1-2205897 Study on subband non-overlapping full duplex Huawei, HiSilicon
40. R1-2205937 Discussion on SBFD operations for NR-duplex InterDigital, Inc.
41. R1-2205960 Discussion of subband non-overlapping full duplex ZTE
42. R1-2205989 Discussion on subband non-overlapping full duplex Spreadtrum Communications
43. R1-2206039 Discussion on subband non-overlapping full duplex vivo
44. R1-2206108 Discussion for subband non-overlapping full duplex New H3C Technologies Co., Ltd.
45. R1-2206117 Considerations on Subband Full Duplex TDD Operations Sony
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47. R1-2206235 Discussion on subband non-overlapping full duplex NEC
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49. R1-2206398 Discussion on subband non-overlapping full duplex CATT
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51. R1-2206505 Discussion on subband non-overlapping full duplex Sharp
52. R1-2206516 Subband non-overlapping full duplex Lenovo
53. R1-2206583 Potential solutions for SBFD in NR systems Intel Corporation
54. R1-2206642 Discussion on subband non-overlapping full duplex Xiaomi
55. R1-2206690 Discussion on subband non-overlapping full duplex China Telecom
56. R1-2206911 Discussion on subband non-overlapping full duplex CMCC
57. R1-2206955 Discussion on subband non-overlapping full duplex enhancements ETRI
58. R1-2206984 Discussion on subband non-overlapping full duplex for NR MediaTek Inc.
59. R1-2207069 Discussion on subband non-overlapping full duplex CEWiT
60. R1-2207118 Discussion on framework for interference mitigation Rakuten Mobile Inc.
61. R1-2207231 Feasibility and techniques for Subband non-overlapping full duplex Qualcomm Incorporated
62. R1-2207261 Discussion on subband non-overlapping full duplex Panasonic
63. R1-2207267 On subband non-overlapping full duplex for NR Nokia, Nokia Shanghai Bell
64. R1-2207335 Views on subband non-overlapping full duplex Apple
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66. R1-2207368 Discussion on subband non-overlapping full duplex KDDI Corporation
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74. R1-2207806 Summary #2 of subband non-overlapping full duplex Moderator (CATT)
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80. R1-2205938 On potential enhancements of dynamic and flexible TDD InterDigital, Inc.
81. R1-2205961 Discussion of enhancements on dynamic/flexible TDD ZTE
82. R1-2205990 Discussion on potential enhancements on dynamic/flexible TDD Spreadtrum Communications
83. R1-2206040 Potential enhancements on dynamic/flexible TDD vivo
84. R1-2206118 Considerations on Flexible/Dynamic TDD Sony
85. R1-2206234 Views on enhancements of dynamic/flexible TDD NEC
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87. R1-2206399 Discussion on potential enhancements on dynamic/flexible TDD CATT
88. R1-2206422 Dynamic and flexible TDD for NR duplex evolution Samsung
89. R1-2206506 Discussion on potential enhancement to dynamic TDD Sharp
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92. R1-2206880 Discussion for potential enhancement on dynamic/flexible TDD New H3C Technologies Co., Ltd.
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97. R1-2207268 Dynamic TDD enhancements Nokia, Nokia Shanghai Bell
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103. R1-2207881 Summary #1 of potential enhancement on dynamic/flexible TDD Moderator (LG Electronics)
104. R1-2207882 Summary #2 of potential enhancement on dynamic/flexible TDD Moderator (LG Electronics)
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RAN4#104e contributions:

[1]. R4-2211561, Impact of SBFD on RF requirements for co-existence in adjacent channel, Qualcomm CDMA Technologies

[2] R4-2211562, Impact of SBFD on RF requirements for self-interference and CLI, Qualcomm CDMA Technologies

[3] R4-2211709, Discussion of the reply LS to RAN1 on interference modelling for duplex evolution, CATT

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[6] R4-2211880, On UE-UE CLI modeling, Apple

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[8] R4-2212117, Discussion on RF requirement for Massive MIMO Antenna for subband non-overlapping full duplex, Kumu Networks

[9] R4-2212146, Views on RF Analysis for Full Duplex, Intel Corporation

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[11] R4-2212161, Clarifying RAN4 work scope for duplex enhancements, MediaTek (Chengdu) Inc

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[14] R4-2212314, SBFD regulatory requirements in China, CMCC

[15]R4-2212485, Initial observations on RF impact due to NR duplex evolution, Samsung

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[18] R4-2212492, On evolution of NR duplex operation, Huawei, HiSilicon

[19] R4-2212493, Reply LS on interference modelling for duplex evolution, Huawei, HiSilicon

[20] R4-2212494, Discussion on the assumptions for co-existence evaluation of Rel-18 duplex evolution, Huawei, HiSilicon

[21] R4-2212495, On regulatory aspects, Huawei, HiSilicon

[22] R4-2212580, Discussion on regulatory aspect of NR duplex evolution, Samsung R&D Institute UK

[23] R4-2212599, Discussion on interference modelling for duplex evolution, Xiaomi

[24] R4-2212619, General considerations for the duplexng enhancements RAN4 work and draft reply LS to RAN1, Ericsson

[25] R4-2212620, Co-channel gNB self interference analysis, Ericsson

[26] R4-2212621, Co-existence considerations for SBFD, Ericsson

[27] R4-2212655, Sub-Band Full Duplex - Regulatory aspects, Ericsson

[28] R4-2212697, Scenarios, assumptions and analysis for SBFD coex study, Samsung

[29] R4-2212801, Discussion on co-existence in adjacent channel for full duplex, vivo

[30] R4-2212802, Discussion on self-interference and CLI for full duplex, vivo

[31] R4-2212847, Adjacent channel coexistence in Sub Band non-overlapping Full Duplex operation, Nokia, Nokia Shanghai Bell

[32] R4-2212848, Self-interference and CLI in Sub Band non-overlapping Full Duplex, Nokia, Nokia Shanghai Bell

[33] R4-2212849, Regulatory considerations on sub-band full duplex operation, Nokia, Nokia Shanghai Bell

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[40] R4-2214377, WF on feasibility study from RF perspective, Samsung

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v04.81 31.07.2018 simplification of template and addition of cross-TSG aspects (for RAN #81)

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v04.75 31.01.2017 minor adaptations for RAN #75

v04.74 28.10.2016 minor adaptations for RAN #74

v04.73 01.09.2016 adaptations for RAN #73 (time units in extra Excel table, RAN6 reporting included)

v04.72 26.05.2016 adaptations for RAN #72 (introduction of NR & GERAN TUs)

v04.71 10.02.2016 minor adaptations for RAN #71

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