

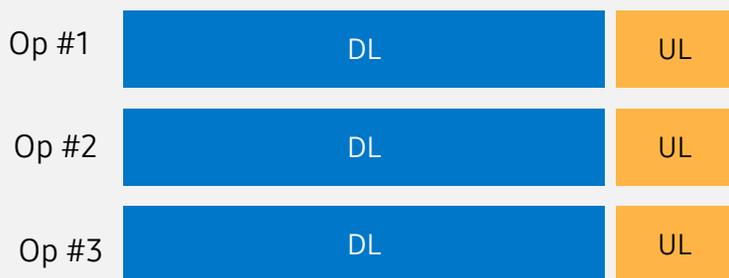
# Duplex Evolution in Rel-19

# Background: need for more spectrum flexibility in NR TDD

## SBFD for improved UL coverage, reduced latency and increased capacity in NR TDD

- Simultaneous existence of DL and UL, a.k.a. more specifically, subband non-overlapping full duplex (SBFD) within a TDD band
- SBFD operation with SIC implemented at the gNB side and half-duplex operation at the UE side

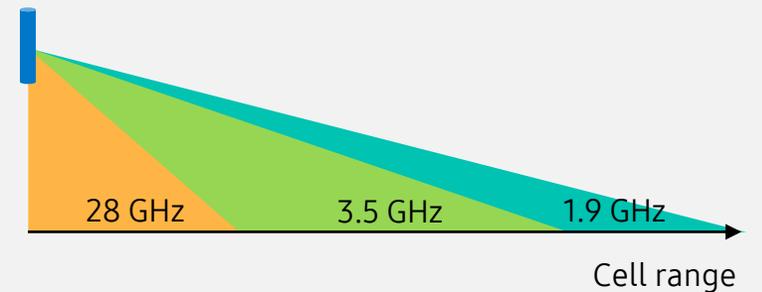
- Inter-operator coexistence relies on static TDD UL-DL configuration 'DDDDU' in macro/micro



- Fixed DL:UL ratio 4:1 limits UL coverage, increases latency and reduces capacity



- Overcoming the UL bottleneck in TDD is critical for deployments in FR1 higher mid-bands and FR2-1



# Background: Rel-18 study item evolution of NR duplex operation

## Detailed SID objectives (RP-223041)

- Identify applicable and relevant deployment scenarios and develop evaluation methodology (RAN1)
- Study the subband non-overlapping full duplex (SBFD) and potential enhancements on dynamic/flexible TDD (RAN1/RAN4)
- Study inter-gNB and inter-UE CLI handling and identify solutions to manage them (RAN1)
- Study the performance of the identified schemes as well as the impact on legacy operation assuming their co-existence in co-channel and adjacent channels (RAN1)
- Study the feasibility of and impact on RF requirements considering adjacent-channel co-existence with the legacy operation and considering the self-interference, the inter-subband CLI, and the inter-operator CLI (RAN4)
- Summarize the regulatory aspects that have to be considered for deploying the identified duplex enhancements in TDD unpaired spectrum (RAN4)

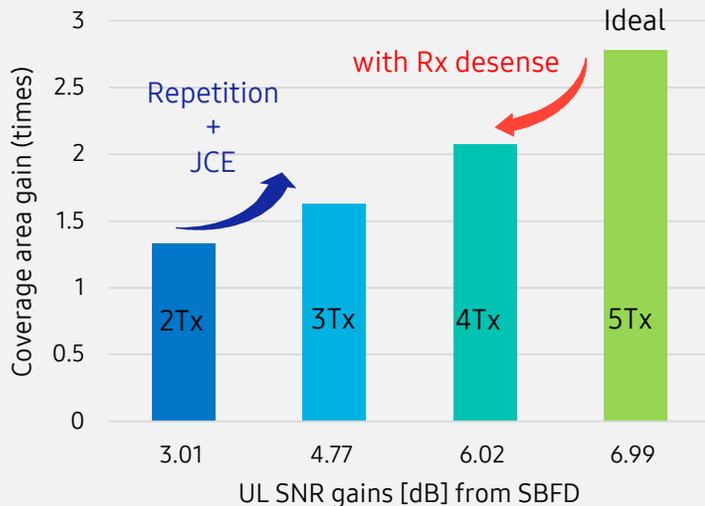
# Motivation

## Benefits from gNB side SBF D operation

- For cell-edge UEs, UL slot utilization ratio is increased from 20% to 80% when transmitting PUSCH/PUCCH repetitions using SBF D UL subband
- For cell edge UEs, PUSCH repetitions in TDD can now benefit from Rel-17 Joint Channel Estimation (JCE) gains (in consecutive SBF D slots)
- For UEs in medium/good SINR conditions, the schedulable UL resources per TDD UL-DL frame configuration period are doubled
- More frequent UL transmission opportunities for PUSCH and PUCCH carrying A/N than are possible with static DDDSU reduce latency

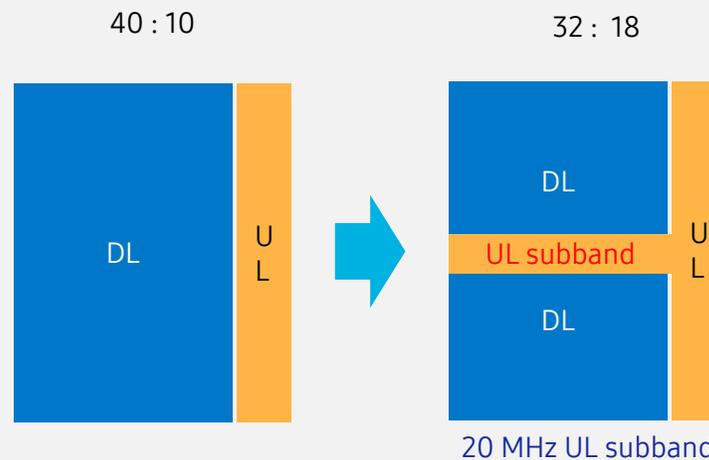
### UL coverage enhancements

- Increased UL slot utilization ratio for PUSCH/PUCCH repetition w/o JCE and/or TBOMs



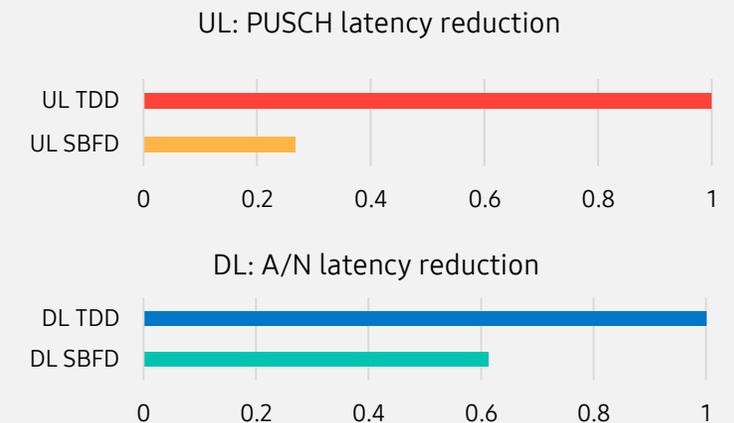
### UL capacity enhancements

- More schedulable UL RBs (resources) for higher instantaneous UL data rate



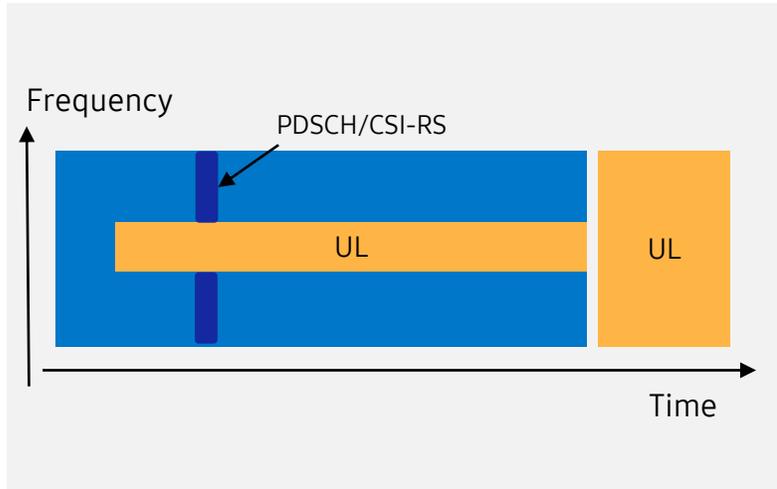
### Latency enhancements

- Increased availability of UL resources for dynamic or configured grant PUSCH and PUCCH carrying A/N or SR



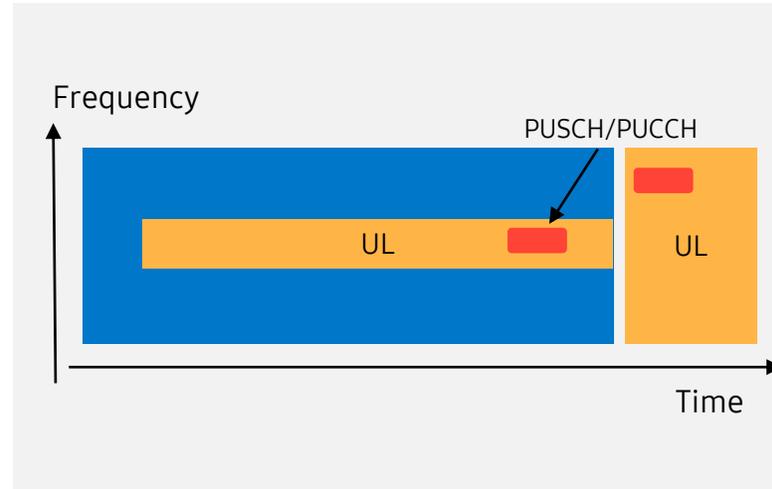
# Expected key features for Duplex Evolution

## DL Subband operations



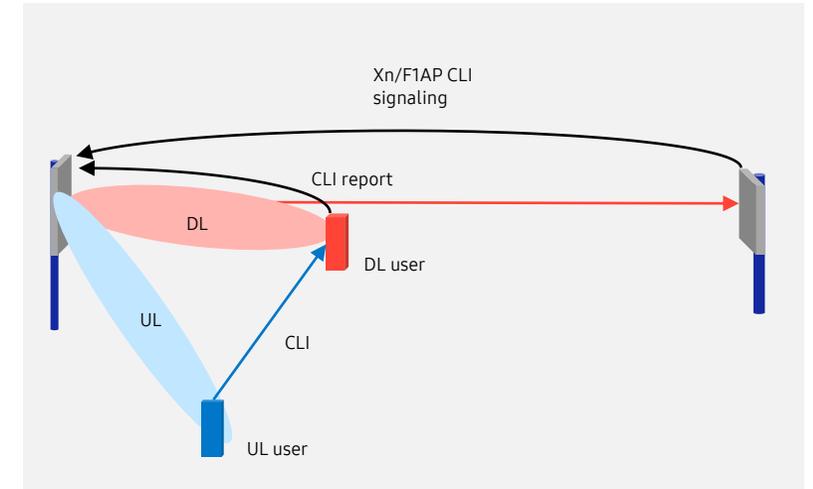
- PDSCH resource allocation across two DL subbands
- CSI enhancement for supporting non-contiguous subbands
- Separate DL link adaptation, and spatial domain settings for the SBFD and non-SBFD slots

## UL subband operations



- PUSCH/PUCCH resource allocation in SBFD slot
- Separate power control, UL link adaptation, and spatial domain settings for the SBFD and non-SBFD slots

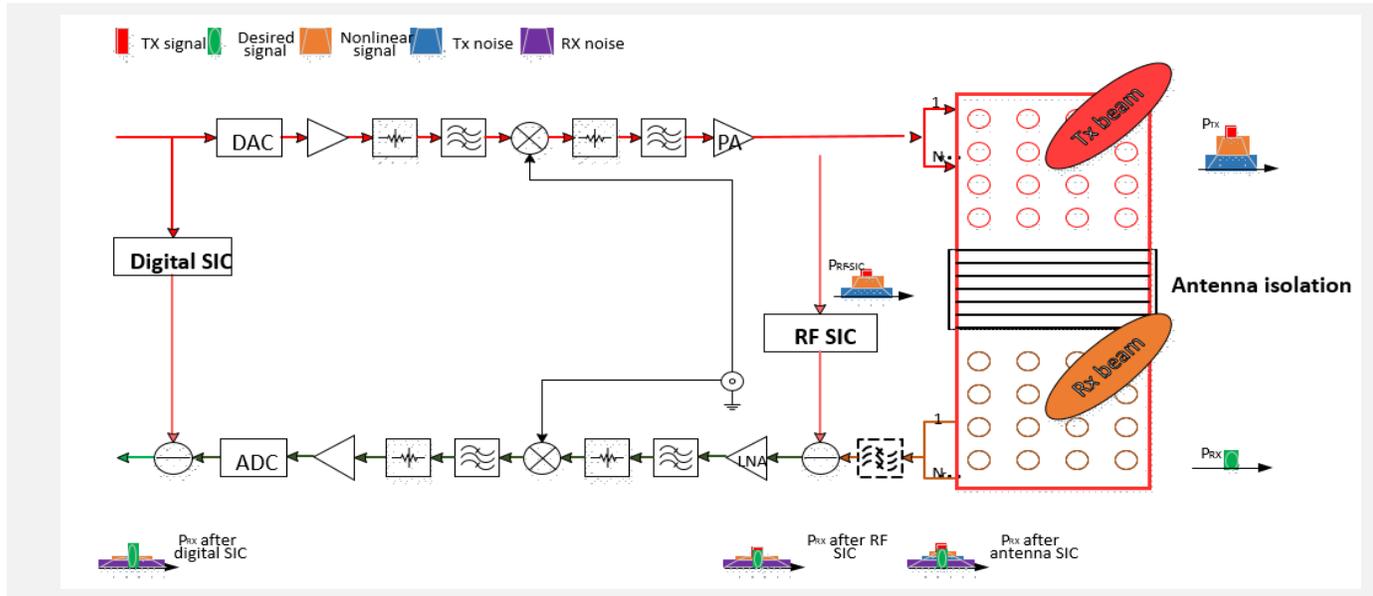
## CLI enhancements



- L1 and/or L2 based UE-to-UE CLI reporting enhancements
- Xn/F1AP signaling enhancements for inter-gNB CLI enhancements

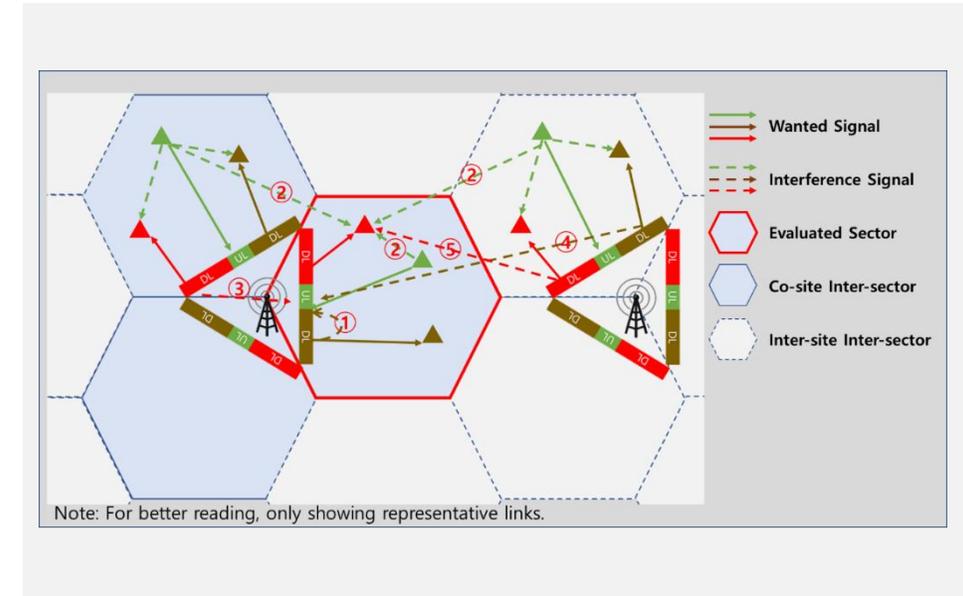
# Feasibility: RAN4 Implementation Study

## Self-Interference and inter-sector interference analysis



- Analysis framework for self-interference and inter-sector interference analysis
  - Open framework encourage all companies' inputs and evaluation on all possible techniques
  - Analysis separated for Wide Area (WA), Medium Range (MR) and Local Area (LA) BS, FR1 and FR2-1.
- Confirmed feasibility (i.e., 150dBc for FR1 WA BS) by considering techniques including:
  - Spatial isolation: TX/RX panel separation and RF barrier structure
  - Frequency isolation: DPD and RX filtering
  - Digital interference cancellation and TX/RX beaming nulling

## Adjacent channel co-existence study

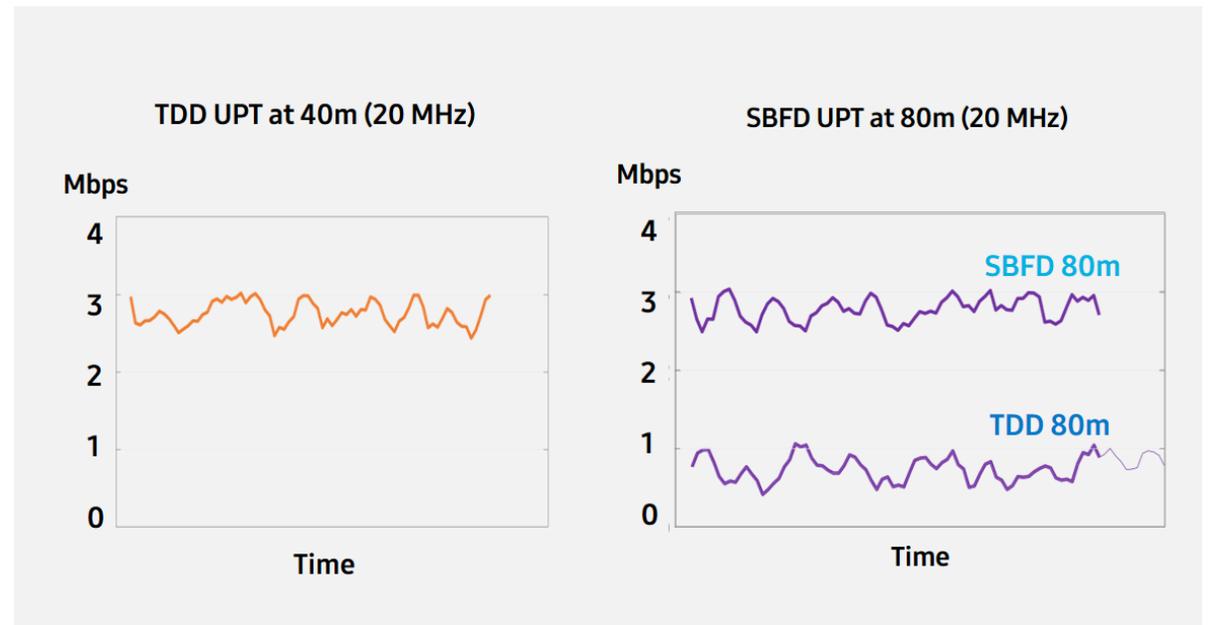


- Adjacent channel co-existence study for RF requirement impact
- Prioritization for SBFD co-existence scenarios
- Preliminary results show acceptable adjacent channel interference from SBFD operation in TDD downlink slot

# Feasibility: UL Coverage test

## Outdoor SBFD test in C-band

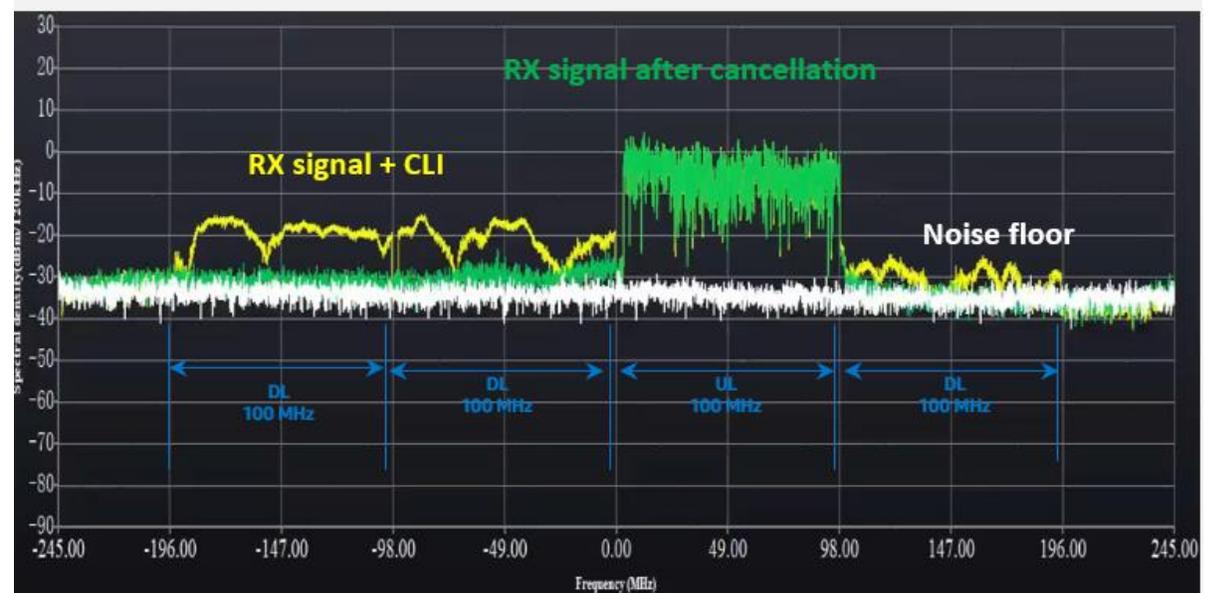
- SBFD PoC features:
  - 16TX-16RX for SBFD gNB (1x3 subarray + X-pol)
  - Antenna SIC + digital SIC
- Bandwidth:
  - 100 MHz TDD spectrum @ 3.4 GHz
  - Subband operation 40 (DL) + 20 (UL) + 40 (DL)
- UL TX mode:
  - 1 slot PUSCH (QPSK) for TDD
  - 5 slots repeated PUSCH (QPSK) for SBFD
- Result:
  - 2.7 Mbps (20% BLER) in TDD @ 40m
  - 0.7 Mbps (80% BLER) in TDD @ 80m
  - 2.8 Mbps (20% BLER) after switching SBFD @ 80m



# Feasibility: UL Throughput

## Outdoor test in mmW band

- SBF-D PoC features:
  - 2TX-2RX panels for SBF-D (256 AE + X-pol)
- Bandwidth:
  - 400 MHz TDD spectrum @ 26 GHz
  - Subband operation 200 (DL) + 100 (UL) + 100 (DL)
- UL TX mode:
  - 1 slot PUSCH (64QAM) for TDD
  - 5 slots repeated PUSCH (64QAM) for SBF-D
- Result:
  - 75.4 Mbps (20% BLER) in TDD 1CA @ 90m
  - 375.5 Mbps (0% BLER) in TDD 1CA @ 90m



# Proposed Rel-19 work item objectives

## Assumptions

- Support for SBF D operation in RRC\_CONNECTED mode
- Semi-static SBF D operation from UE perspective, i.e., no support for dynamic SBF D

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## RAN1

### Physical-layer support for SBF D operations

- PUSCH/PUCCH/PDSCH resource allocation enhancements
- CSI-RS resource/CSI reporting enhancements
- Separate control of power control, link adaptation, spatial domain settings for the SBF D and non-SBF D slots
- UE-to-UE CLI reporting enhancements

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## RAN2/3

### RAN2

- Signaling for SBF D subband configuration and inter-UE CLI reporting enhancements

### RAN3

- Xn/F1AP signaling enhancements for inter-gNB CLI enhancements

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## RAN4

### RAN4 (core part):

- BS RF core requirements for SBF D operation (intra/inter-carrier SBF D)
- (SBF D-aware) UE RF core requirements (if any)
- RRM core requirements identified for SBF D operation (if any)
- RRM core requirements for UE-UE CLI measurement/reporting for SBF D

### RAN4 (perf. part):

- BS RF conformance requirements
- RRM performance requirements for SBF D operation (if any)
- RRM performance requirements for UE-UE CLI meas./reporting for SBF D
- Demodulation performance requirements for SBF D operation (if any)