

China Academy of Telecommunication Technology

3GPP TSG RAN Meeting #102

Edinburgh, Scotland, December 11<sup>th</sup>-15<sup>th</sup>, 2023

大唐电信集团 RP-233012

## On Rel-19 MIMO enhancements

CATT

# Background

- In previous releases, the following enhancements have been specified in MIMO for 5G NR

Items	Details
Beam Management	Rel-16: BFR for Scell; L1-SINR based beam reporting; MAC-CE based beam selection enhancement Rel-17: Unified TCI framework for DL and UL beam indication; Panel-specific beam selection for UL; Enhancements for higher intra- and L1/L2-centric inter-cell mobility Rel-18: Extension of Rel-17 Unified TCI framework to M-TRP deployment scenarios
CSI	Rel-16: eType II CSI feedback Rel-17: CSI reporting for NCJT; Type II port selection codebook enhancement by utilizing DL/UL reciprocity of angle and delay Rel-18: Rel-16/17 Type-II codebook refinement for CJT M-TRP; Rel-16/17 Type-II codebook refinement and UE reporting of time-domain channel properties for high/medium UE velocities
UL MIMO	Rel-16: Full power transmission Rel-17: TDM based M-TRP PUSCH/PUCCH Rel-18: UL 8Tx; STxMP of PUSCH/PUCCH; 2TA for M-DCI M-TRP; power control for S-DCI M-TRP
Multi-TRP/panel transmission	Rel-16: NCJT PDSCH Rel-17: TDM based M-TRP PUSCH/PUCCH; M-TRP PDCCH; enhancement for HST-SFN deployment scenarios(PDCCH/PDSCH); beam reporting enhancement for M-TRP; BFR for M-TRP; QCL/TCI-related enhancements for inter-cell M-TRP Rel-18: STxMP of PUSCH/PUCCH; 2TA for M-DCI M-TRP; power control for S-DCI M-TRP; Rel-16/17 Type-II codebook refinement for CJT M-TRP
Reference signals	Rel-16: CSI-RS and DMRS enhancement for PAPR reduction Rel-17: Flexible aperiodic SRS triggering; SRS switching for up to 8 antennas; Enhancement for SRS capacity and/or coverage Rel-18: Larger number of orthogonal DMRS ports for MU-MIMO; SRS for UL 8Tx; SRS for CJT

- Targeting higher system performance, higher system efficiency and reliability, further enhancements on beam management, UL MIMO, CJT M-TRP transmission and CSI are expected.

# Background

- Several proposals were submitted to previous meetings which were summarized in RP-232612.
- As indicated in RAN Chair's summary (RP-232745), down scoping of the objectives for Rel-19 MIMO is still needed to fit the allocated TUs.

📶 References: [RWS-230488](#), [RP-231540](#), [RP-232612](#)

📶 Potential objectives:

**[To discuss in RAN#102 according to the TU budget, particularly the necessary down-scoping of the yellow part]**

- **Topic 1: Beam management enhancements to reduce overhead/latency through UE-initiated/event-driven beam management**
  - Objective 1: Signalling/mechanism to facilitate UE-initiated beam management procedure including UE-initiated beam reporting/[switch]
- **Topic 2: Enhancements to CSI framework to support > 32 (64/128) CSI-RS ports**
  - Objective 1: Type I codebook enhancements to support > 32 CSI-RS ports
  - Objective 2: Type II codebook enhancements to support > 32 CSI-RS ports
  - Objective 3: Hybrid beamforming enhancements (CRI based reporting enhancements)
  - Note 1: Extension of legacy codebooks and legacy CSI-RS resources
  - Note 2: Objective 3 may require further study or clarification.
- **Topic 3: CJT/DL multi-TRP enhancements**
  - Objective 1: UE-assisted calibration reporting of delay and frequency/phase offsets for CJT with non-ideal synchronization and backhaul
  - Note: Assume legacy CSI-RS design and standalone aperiodic reporting on PUSCH.

## Topic 4: UL enhancements

Objective 1: STxMP enhancements (e.g. Simultaneous TX of PUCCH and PUSCH, Asymmetric panel implementations, mDCI PUCCH + PUCCH, STxMP with up to rank 8, Coherent SFN STxMP)

Objective 2: Enhancements for UL 3Tx including 3Tx for UL codebook and non-codebook based transmission

## Topic 5: Enhancement for asymmetric downlink S-TRP/UL M-TRP scenario assuming intra-band intra-cell non-co-located M-TRP scenarios without changing existing cell definition or defining a new cell

Objective 1: Extension of Rel-18 2TA mDCI to sDCI assuming legacy PRACH resources

Objective 2: Separate UL power control for SRS only to downlink S-TRP from SRS to UL M-TRP and introduce path loss measurement to uplink M-TRP

## Topic 6: 6Rx/8Rx UE enhancements with lower complexity utilizing two segments of 3/4 Rx antenna units up to 8-layer DL Tx based on legacy codebook and legacy codeword to layer mapping

Objective 1: SRS antenna port grouping, CSI and codeword association to the segments of receive antenna.

# Beam management enhancement

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- **Motivation**

- The beam change due to UE rotation/movement is not predictable from gNB side.
- UE initiated beam management is helpful to reduce both latency and UL resource overhead.
- Considering scheduling flexibility of NW, switching of beam should be determined by gNB instead of UE.

- **Potential enhancements**

- UL signaling content(s) for UE-initiated/event-driven beam reporting or beam management triggering request.
- UL signaling medium/container for UE-initiated/event-driven beam reporting or beam management triggering request.
- Procedure after gNB receive the UL signaling, i.e., gNB response to UL signaling.

- **Proposal**

- Rel-19 UE-initiated beam management should focus on beam reporting.

# UL MIMO enhancement

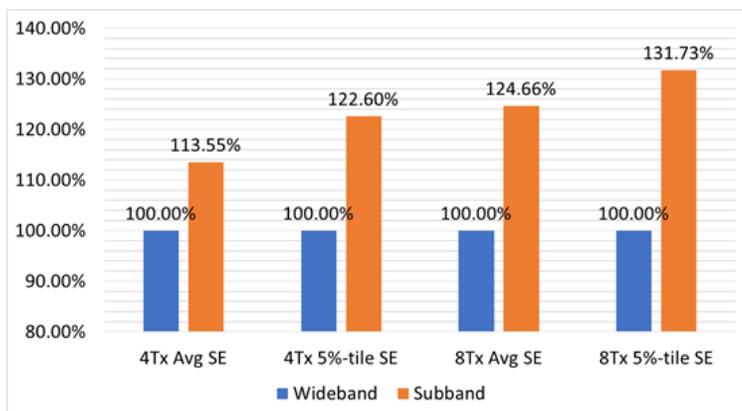
## Frequency-selective precoding

- **Motivation**

- The allocated bandwidth of UL can be substantially wide (e.g. up to 100MHz in FR1 and up to 400MHz in FR2), frequency-selective precoding can provide full utilization of frequency-selectivity of UL channel and improve UL UPT.

- **Proposal**

- Frequency-selective precoding for codebook based PUSCH transmission is supported in Rel-19.



Frequency-selective precoding vs. wideband precoding, 100MHz system bandwidth @3.5GHz

## Enhancements for UL 3Tx

- **Background**

- It was proposed in previous meetings to support 3Tx for UL MIMO in Rel-19 to improve UL performance.
- The workload for UL 3Tx can be quite heavy if the followings are specified: full-coherent and partial-coherent codebook, 3-port SRS resource and UL full power transmission.
- In order to reduce the workload to fit MIMO TUs, the scope of 3Tx shall be limited.

- **Proposal**

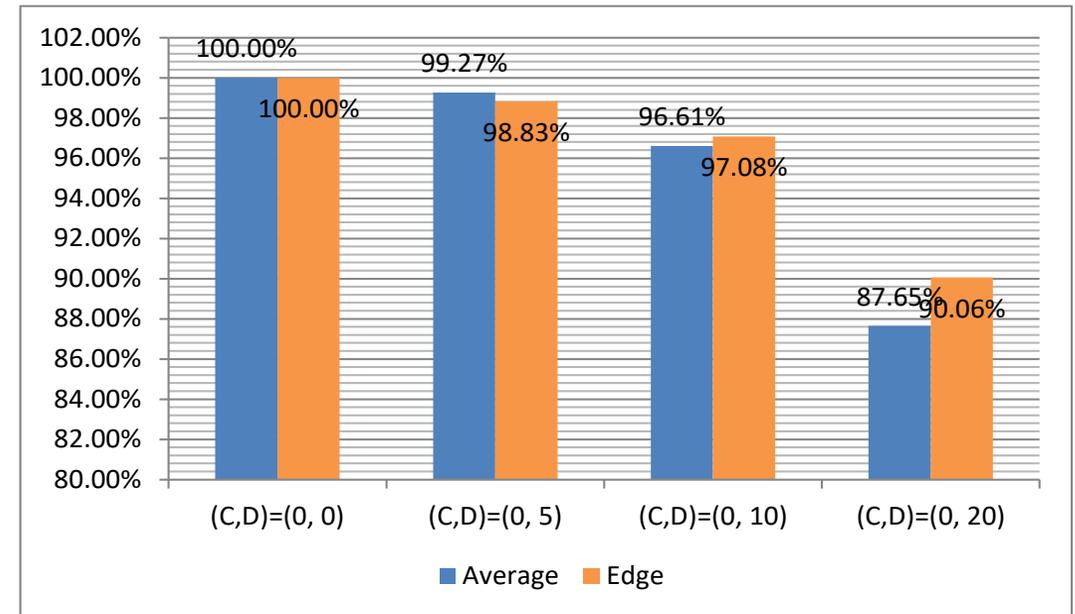
- For enhancement for 3Tx UL MIMO, limit the scope to non-coherent codebook-based transmissions, without enhancement on UL full power transmission and without enhancement on SRS resource.

# Enhancement for CJT

## • Motivation

- Rel-18 specifies enhanced Type II codebook to support CJT assuming ideal backhaul and synchronization.
- Non-ideal reciprocity and non-ideal synchronization will degrade the performance of CJT transmission.
- Solutions to deal with non-ideal reciprocity and synchronization is crucial for commercial deployment of CJT.

- System level evaluation is conducted to assess the impact of reciprocity error on CJT.
- Reciprocity modeling:
  - The DL channel and UL channel of TRP  $i$  :
  - $\mathbf{H}_{DL,i} = \mathbf{H}_{UL,i}^T \beta_i e^{j\varphi_i}$
  - where  $\beta_i$  is amplitude error, which follows  $(0, C\text{dB})$  log-normal distribution,
  - $\varphi_i$  is phase error, which follows  $[-D, D]$  degree uniform distribution
- Trans. scheme: MU-MIMO + CJT (among 3 TRPs).
- Antenna configuration for each TRP:  $(M, N, P, M_g, N_g; M_p, N_p) = (4, 2, 2, 1, 1; 4, 2)$
- **Observation:** When the phase error grows to 20 degrees, the system performance degrades by more than 10%.

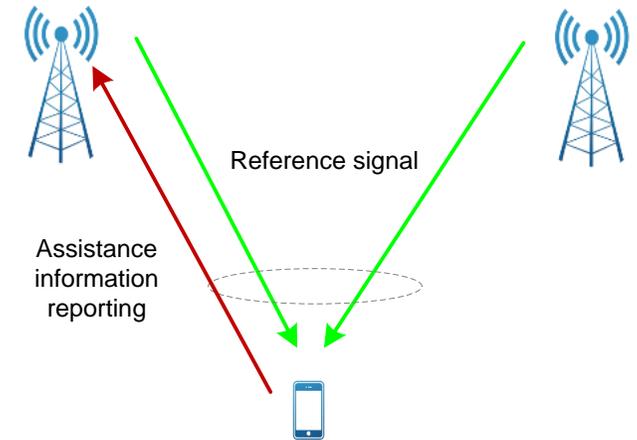


Impact of reciprocity error on CJT

# Enhancement for CJT

- **Potential solutions**

- Non-ideal reciprocity compensation
  - BS transmits reference signals, UE measures and reports phase offsets (assistance information) among TRPs.
  - UE transmits SRS for BS to measure UL channel.
  - BS estimates calibration coefficients by reported offsets and UL channel.
  - BS calculates DL precoders according to the measured UL channel and estimated calibration coefficients.
- Non-ideal time synchronization compensation
  - UE reports time/phase offset (assistance information) to reflect time misalignment.
  - BS pre-process signal based on the assistance information to ensure that the receiving signal is synchronized at UE.
- Non-ideal frequency synchronization compensation
  - UE reports frequency/phase offset (assistance information) to reflect frequency misalignment.
  - BS pre-process signal based on the assistance information to ensure that the receiving signal is synchronized at UE.



- **Proposal**

- Specify UE reporting enhancement for CJT deployments under non-ideal synchronization and backhaul, targeting FR1, both FDD and TDD
  - Inter-TRP time misalignment and frequency/phase offset measurement and reporting, assuming legacy CSI-RS design, with stand-alone aperiodic reporting on PUSCH.

# Enhancements of CSI to support >32 CSI-RS ports

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- **Motivation**

- Three objectives are under consideration for enhancement to support > 32 CSI-RS ports.
- If all of the three objectives are adopted in Rel-19, the scope shall be carefully selected to fit the allocated TUs.
- For Type II codebook enhancement, the workload can be quite heavy if new codebook is designed with all the codebook parameters investigated.
- For hybrid beamforming enhancement, workload is also heavy if new codebook is designed.
- To fit MIMO TUs, we propose to limit the scope of Type-II codebook enhancement and hybrid beamforming enhancement.

- **Proposal**

- On enhancements of CSI to support >32 CSI-RS ports,
  - For Type-II codebook refinement, only extension of legacy codebooks is supported, without modifying any codebook parameter other than introducing additional values for the number of ports.
  - For extension of CRI(s)-based CSI reporting for hybrid beamforming, no new codebook designed.

# Conclusion

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- **Beam management**

- Proposal: Rel-19 UE-initiated beam management should focus on beam reporting.

- **UL MIMO**

- Proposal: Frequency-selective precoding for codebook based PUSCH transmission is supported in Rel-19.
- Proposal: For enhancements for 3Tx UL MIMO, limit the scope to non-coherent codebook-based transmissions, without enhancement on UL full power transmission and without enhancement on SRS resource.

- **CJT**

- Proposal: Specify UE reporting enhancement for CJT deployments under non-ideal synchronization and backhaul, targeting FR1, both FDD and TDD
  - Inter-TRP time misalignment and frequency/phase offset measurement and reporting, assuming legacy CSI-RS design, with stand-alone aperiodic reporting on PUSCH.

- **CSI**

- Proposal: On enhancements of CSI to support >32 CSI-RS ports,
  - For Type-II codebook refinement, only extension of legacy codebooks is supported, without modifying any codebook parameter other than introducing additional values for the number of ports.
  - For extension of CRI(s)-based CSI reporting for hybrid beamforming, no new codebook designed.

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