

# SBFD operation for random access in Rel-19 NR duplex evolution



# Introduction

- **To provide enhanced UL coverage, reduced latency, and improved system capacity of TDD system, Rel-18 SI on evolution of NR duplex operation was approved in RAN plenary #94-e meeting and is on-going now.**
  - There are two duplex enhancement techniques: SBFD (sub-band non-overlapping full duplex) and dynamic TDD enhancements.
  - However, due to the lack of spectrum, most of operator has other operators which use the same and synchronized TDD pattern in adjacent band and it makes SBFD is more feasible solution in terms of deployment possibility.
- **Regarding SBFD based UL coverage enhancement, identifying NR coverage bottleneck in live network using FR1 TDD spectrum is important for deciding scope of potential follow-up Rel-19 NR duplex evolution WI.**
  - Mid-band (e.g., 3.5GHz) is widely used TDD spectrum in commercial NR deployments globally.
- **So, we discuss the NR coverage bottleneck based on live network measurement in FR1 TDD spectrum and related enhancement aspects for Rel-19 NR duplex evolution.**

# Discussion

- **Observation 1: Even if there are sufficient PRACH preamble formats in specification, limited continuous time duration for the uplink in TDD limits its allocation flexibility in real network.**
  - For 'DDDSU' pattern with 30kHz SCS (=0.5ms UL slot duration), only short PRACH preamble sequence can be used.
  - Even if we do not use any cyclic shifts on each PRACH root sequences (i.e., zero correlation zone config = 0), maximum PRACH detection distance with 30kHz SCS is 4.6km as shown in below.

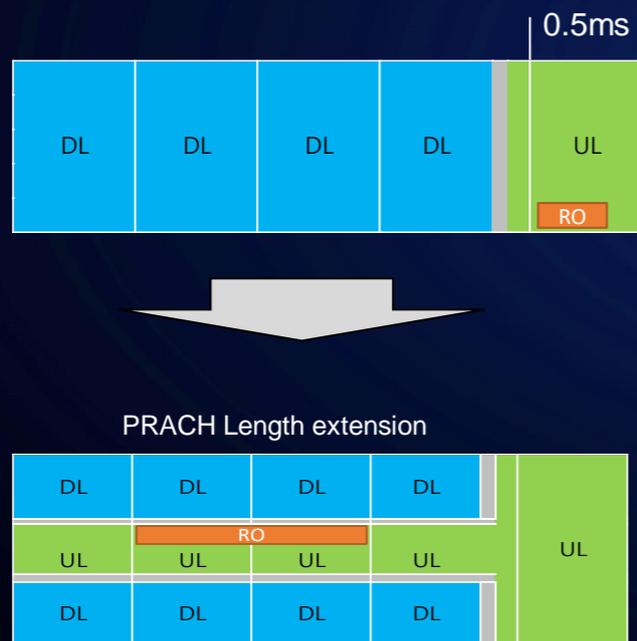


Table 1. NR PRACH cell dimensioning [1]

Category	Format	Maximum Cell Radius (m)			
		15kHz SCS	30kHz SCS	60kHz SCS	120kHz SCS
Short	A1	939	448	224	112
	A2	2110	871	435	217
	A3	3517	1302	651	325
	B1	586	232	116	58
	B2	1055	475	237	118
	B3	1758	871	435	217
	B4	3869	1302	651	325
	C2	9301	4648	2324	1162
Long	0	12364 (SCS 1.25kHz)			
	1	57427 (SCS 1.25kHz)			
	2	22910 (SCS 5kHz)			
	3	14759 (SCS 5kHz)			

[1] Arvind Chakrapani, "On the Design Details of SS/PBCH, Signal Generation and PRACH in 5G-NR," IEEE Access, July 2020.

# Discussion

- **Observation 2: In LOS environment (ex. rural with no high-rise building, sea-side area), mid-band NR TDD coverage is limited by possible PRACH detection distance (not UL data channel) in our live network measurement.**
  - By changing PRACH SCS from 30kHz to 15kHz, we can see that mid-band NR coverage can be extended double (4km → 9km).

Figure 1. Mid-band NR coverage measurement with 30/15kHz PRACH SCS

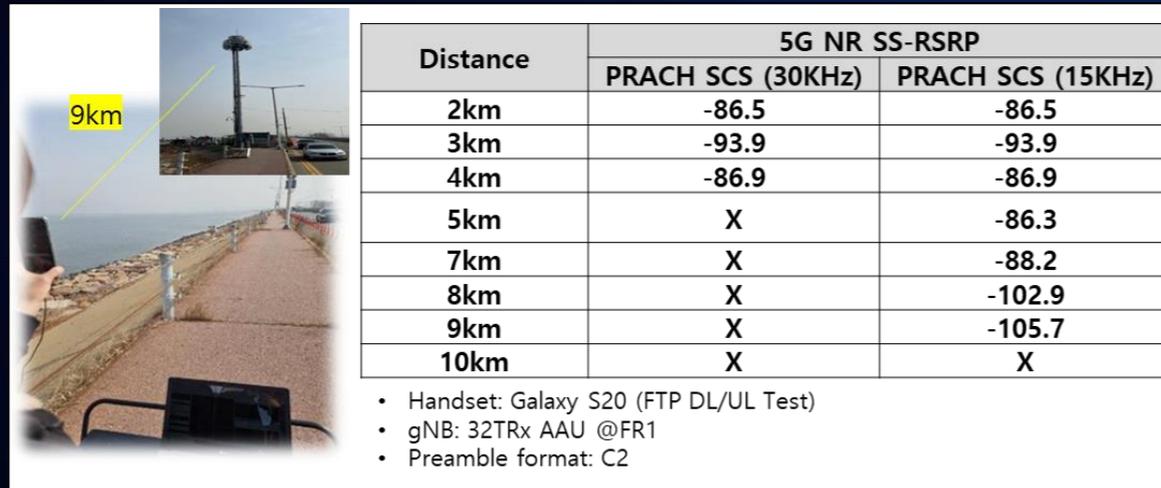


Table 2. Mid-band NR QoS coverage (UL 1Mbps, @3.65GHz)

Direction	QoS	UL 1Mbps	
		DDDSU	FDD (or XXXXU)
Tx	UE Tx Power (dBm)	23	23
	Duplex (DL/UL)	DDDSU	FDD (or XXXXU)
	UL RB	75	28
	MCS	0	0
	UE EIRP (dBm/RB)	4.2	8.5
Rx	BS Antenna Gain (dBi)	24.9	24.9
	Thermal Noise (dBm/RB)	-118.2	-118.2
	BS Noise Figure (dB)	4.0	4.0
	Thermal Noise at BS Rx (dBm/RB)	-114.2	-114.2
	Required SNR (dB)	-3.0	-3.0
	Received Signal Strength (dBm/RB)	-117.2	-117.2
Max Allowable Pathloss (dB)		146.4	150.7
Max 2D Distance (UMa LOS, @3.65GHz, km)		9.15km	12.4km

- **Observation 3: Expected increase of UL QoS coverage (ex. 9.15km → 12.4km) based on SBFDD operation can not be utilized if there is no corresponding random access coverage improvement.**
  - SBFDD operation in data channel can enhance the NR data channel QoS coverage by utilizing increasing UL scheduling chance to reduce UL RB & MCS per each transmission.

# Conclusion

- Based on the previous observations, we strongly suggest as following;
- **Proposal:** Random access coverage enhancement using SBFD operation in RRC idle/inactive state should be specified in Rel-19 NR duplex evolution.

**Thank You.**

