

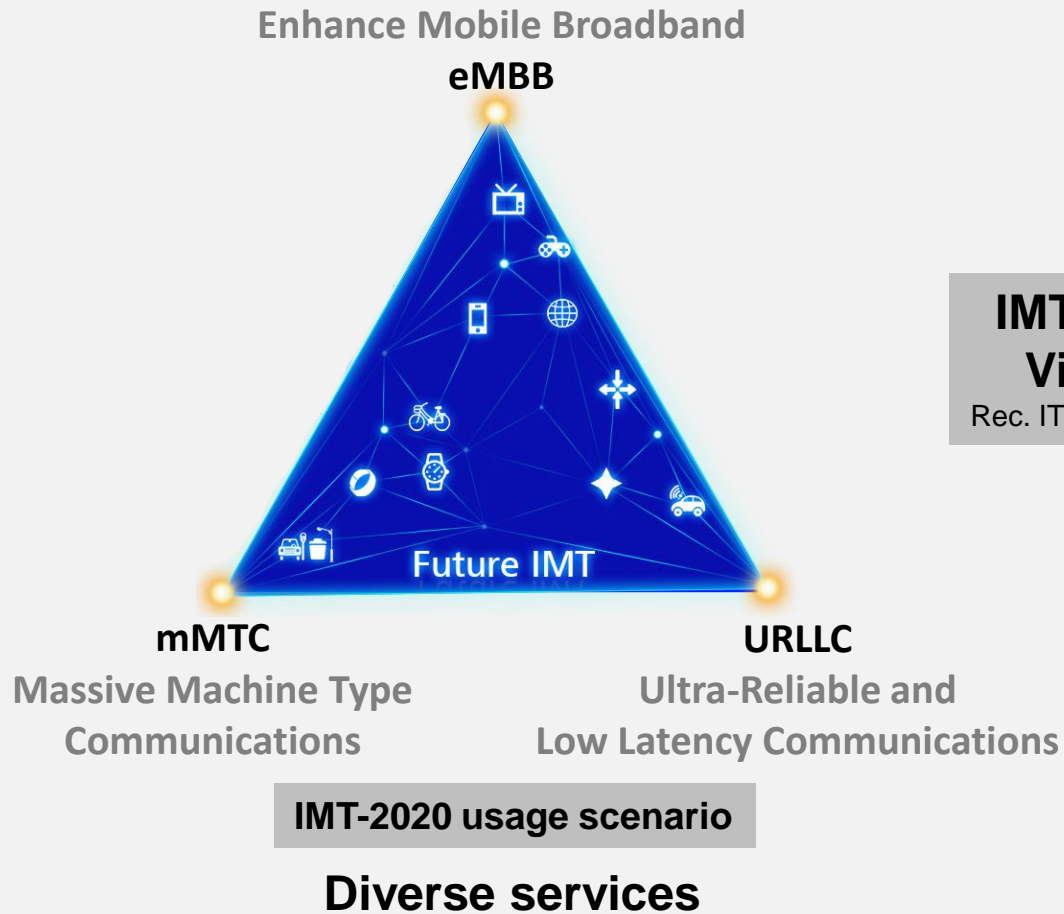


# When technology meets spectrum: Bring 5G vision into Reality

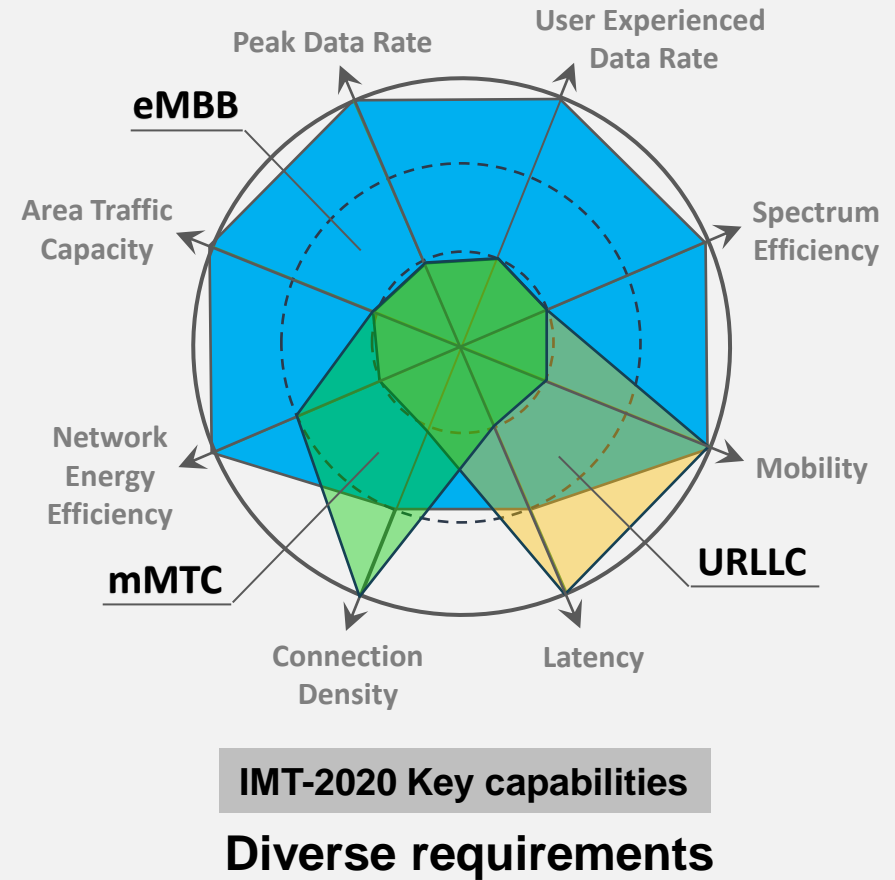
5G India 2018, 2<sup>nd</sup> international conference  
(May 17-18, 2018)

WU Yong

# 5G Vision: Enabling a full connected world



**IMT-2020 Vision**  
Rec. ITU-R M.2083



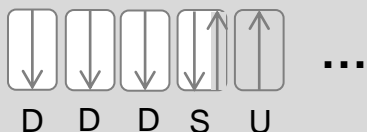
**How to realize the broad vision through 5G technology and spectrum?**

# 3GPP 5G technology:

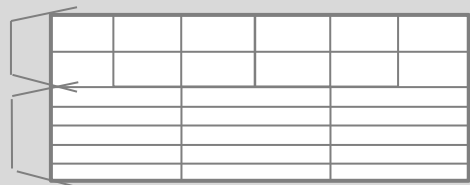
## Unified framework for diverse requirements

NR frame structure  
Numerology, and waveform

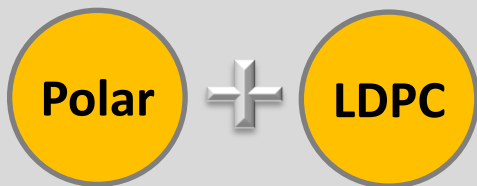
- Flexible frame structure



- Multiple numerologies and OFDM based waveform (f-/w-OFDM)



NR Channel coding,  
and modulation



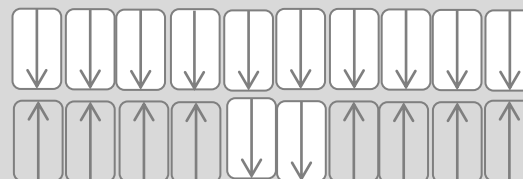
**For control channel;**  
Polar is robust for small data and has good coverage.

**For data channel;** LDPC can fast decode large amount of data in a cost efficient manner.

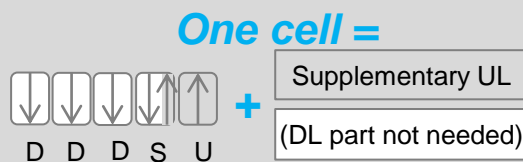


NR flexible duplex and  
flexible spectrum use

- Flexible duplex for both paired and unpaired spectrum

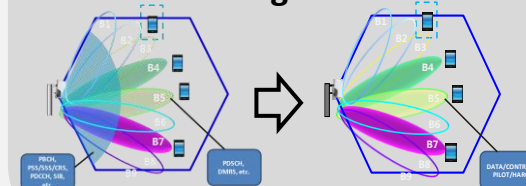


- Flexible spectrum use including TDD + SUL



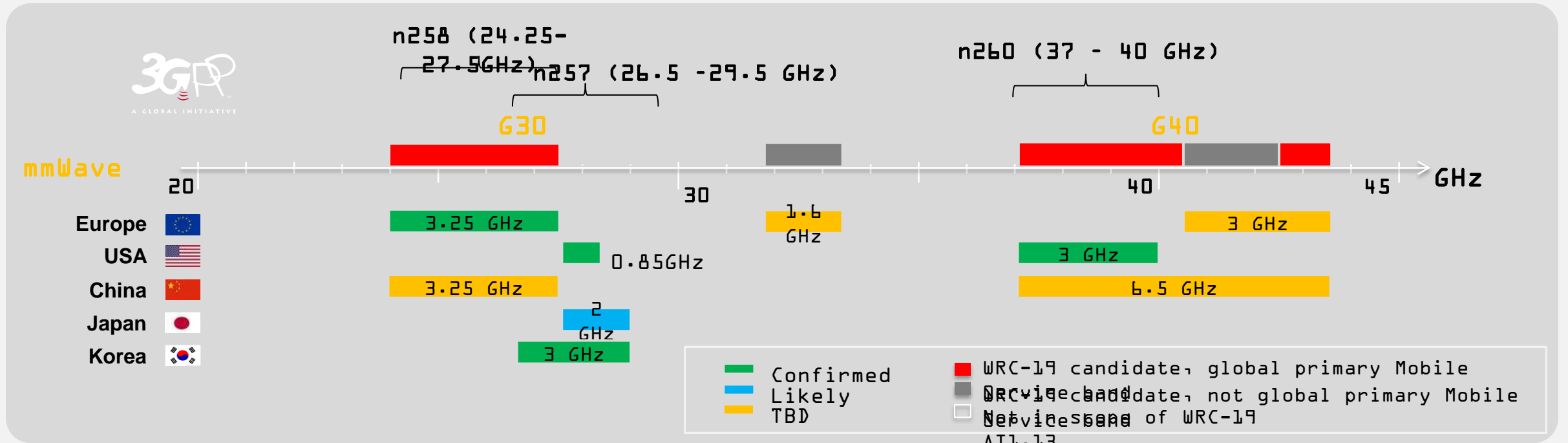
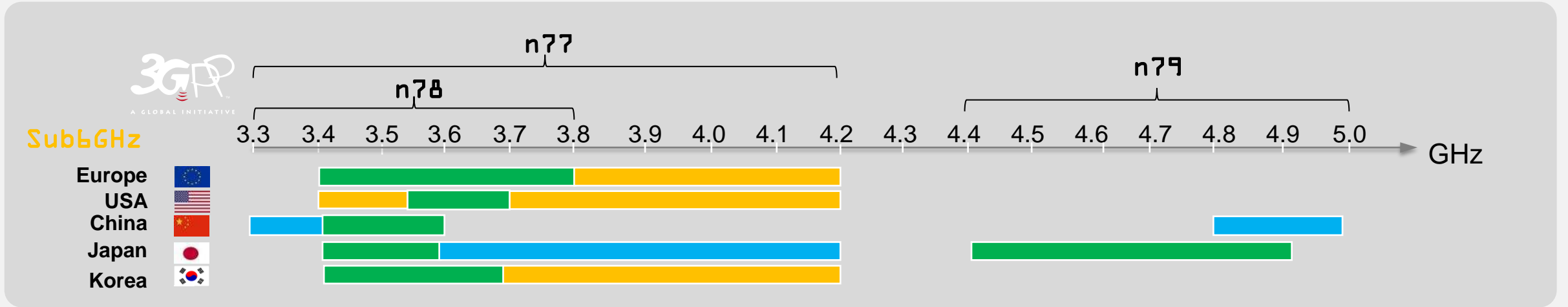
NR Massive MIMO

- Unified MIMO framework for control and data
- Signaling & feedback enhancement with more accurate CSI
- Beamforming enhancement: Hybrid baseband & analog beamforming

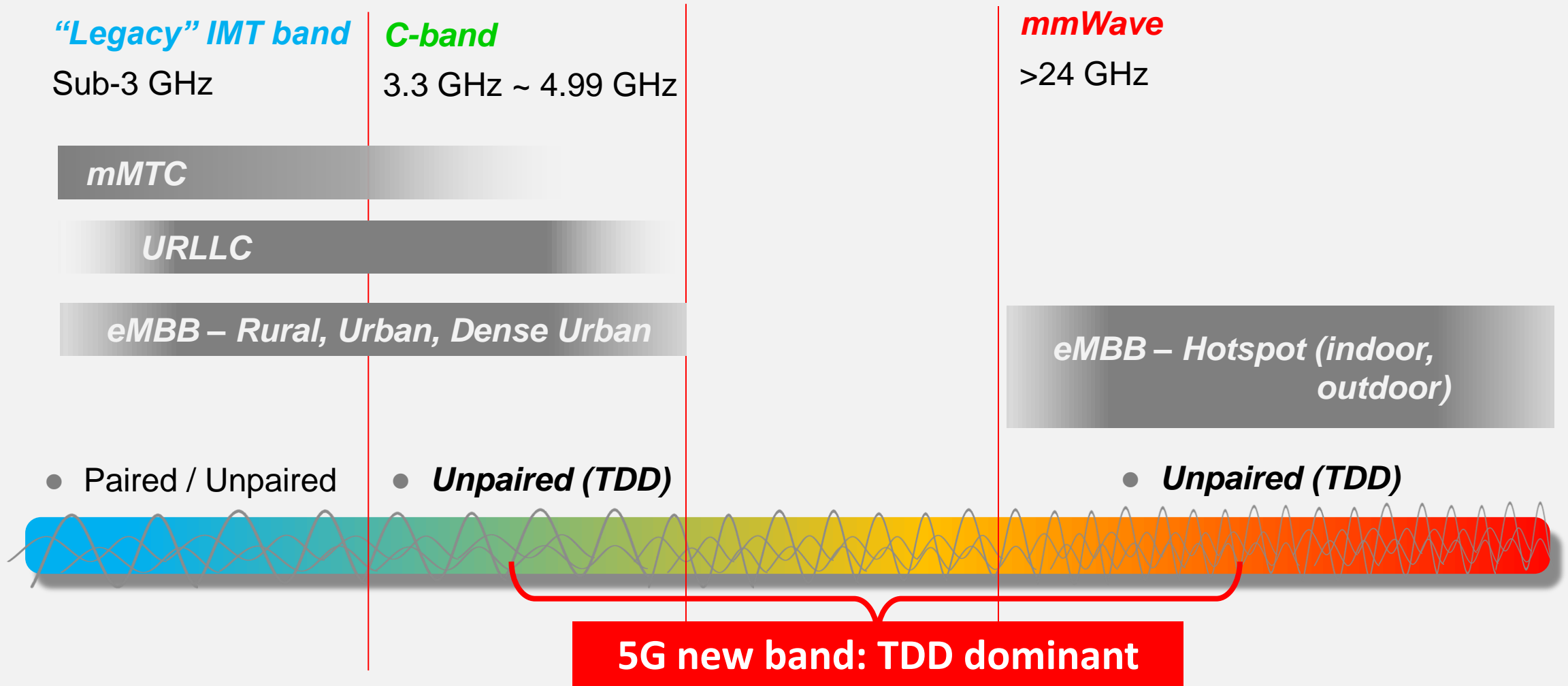


Full spectrum support from 0.5 GHz to mmWave

# 5G spectrum: C-band/G30/G40 Potentially Global Harmonized

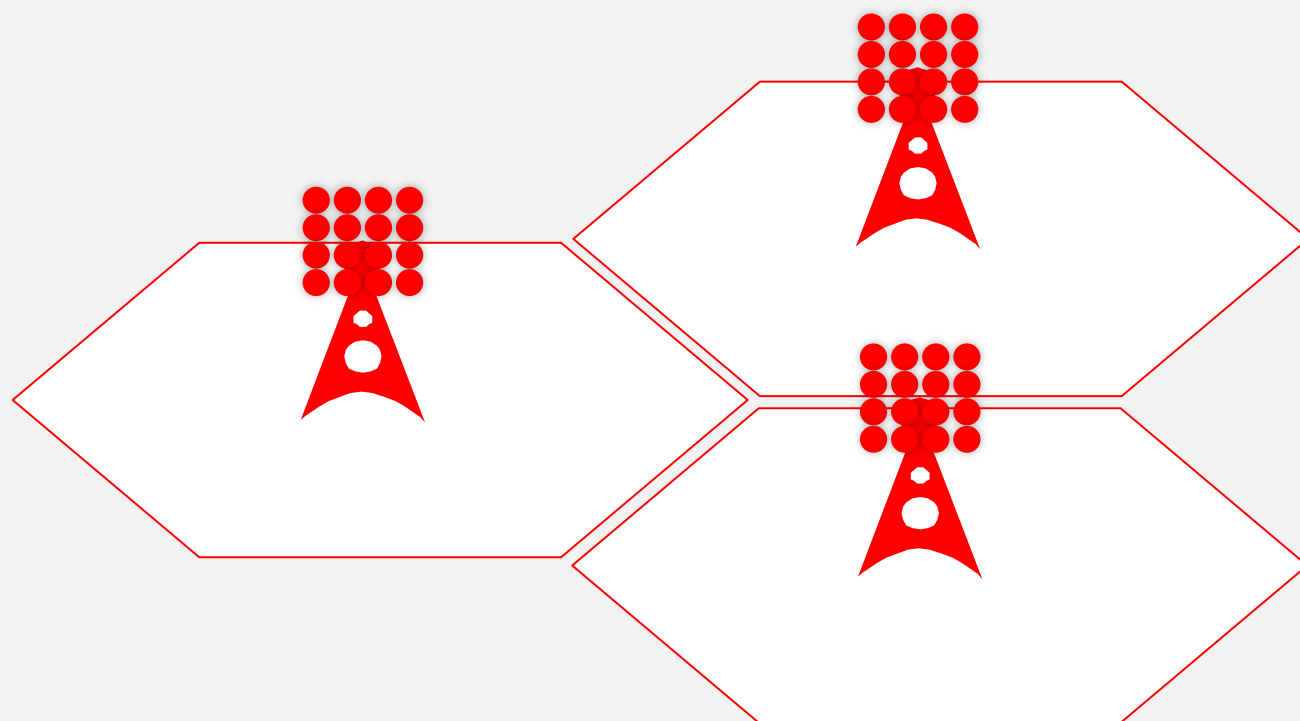


# 5G spectrum map for 5G vision



## Early 5G deployment:

# Macro site with C-band is a trend



- **C-band:**  
good trade off  
of bandwidth  
and coverage

- **Macro site  
deployment:**  
fast re-use  
available sites



**Fast and cost-efficient 5G  
deployment is made possible.**

*How to make it  
work?*

*How to guarantee  
coverage?*



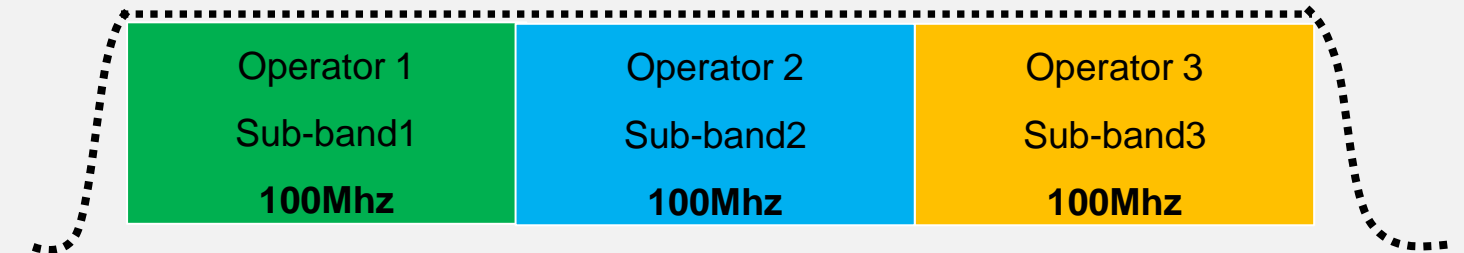
# Inter-operator Synchronization

## Desired for C-band macro site

Asynchronous 5G NR TDD Requires  $>25\text{MHz}$  Guard-band among operators

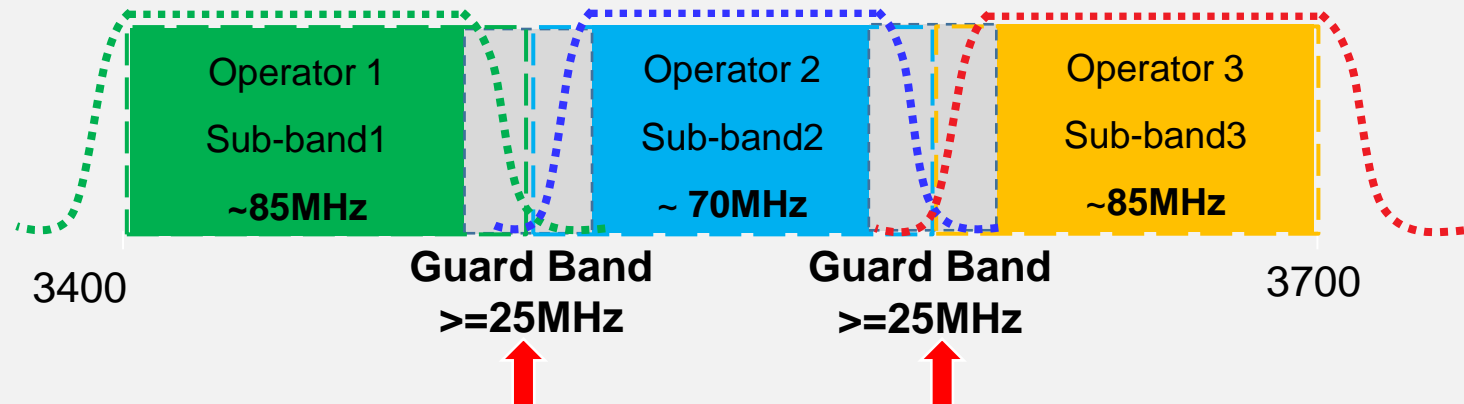
### Synchronous Operation

- Global eco-system
- Band specific receiver filter design(cheap)
- Common frame structure among operators



### Asynchronous Operation

- Operator specific receiver filter design(very expensive)
- Inter-operator Guard Band  $\geq 25\text{MHz}$

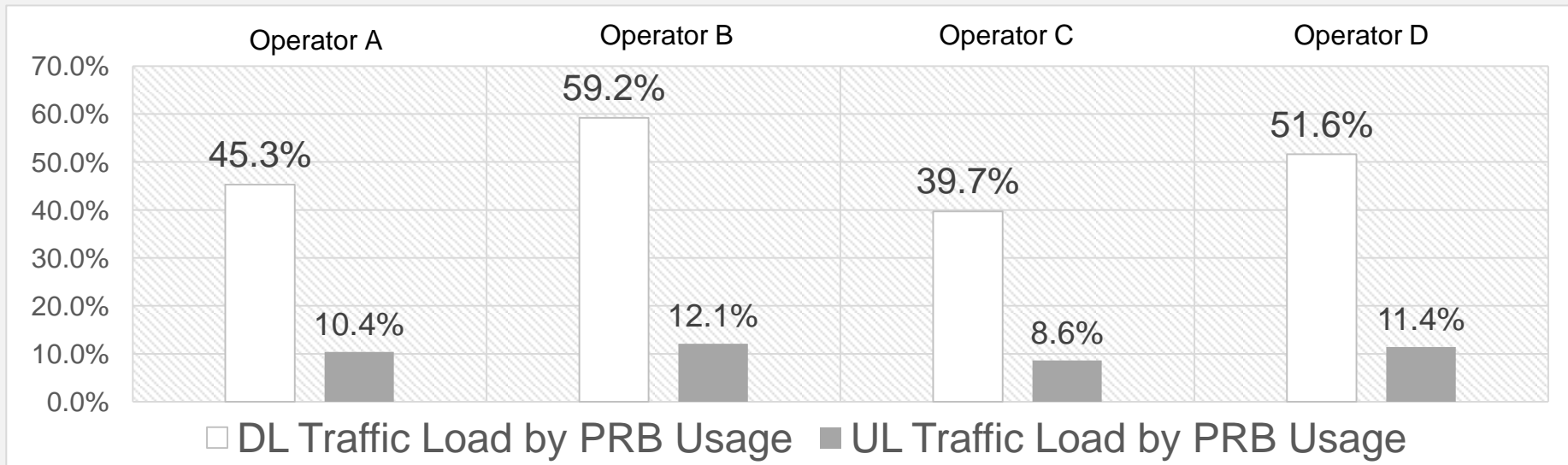


For avoiding Interference , Unsynchronized Scenario  
ECC Spurious emission requirement  $<-43\text{dBm}/5\text{MHz TRP}$

# Unified frame structure for macro site

- The unified frame structure needs to be selected for the synchronized macro site deployment.
- An average DL:UL utilization ratio of around **4:1** for typical scenario is observed.

Typical operator's average DL:UL radio resource ratio

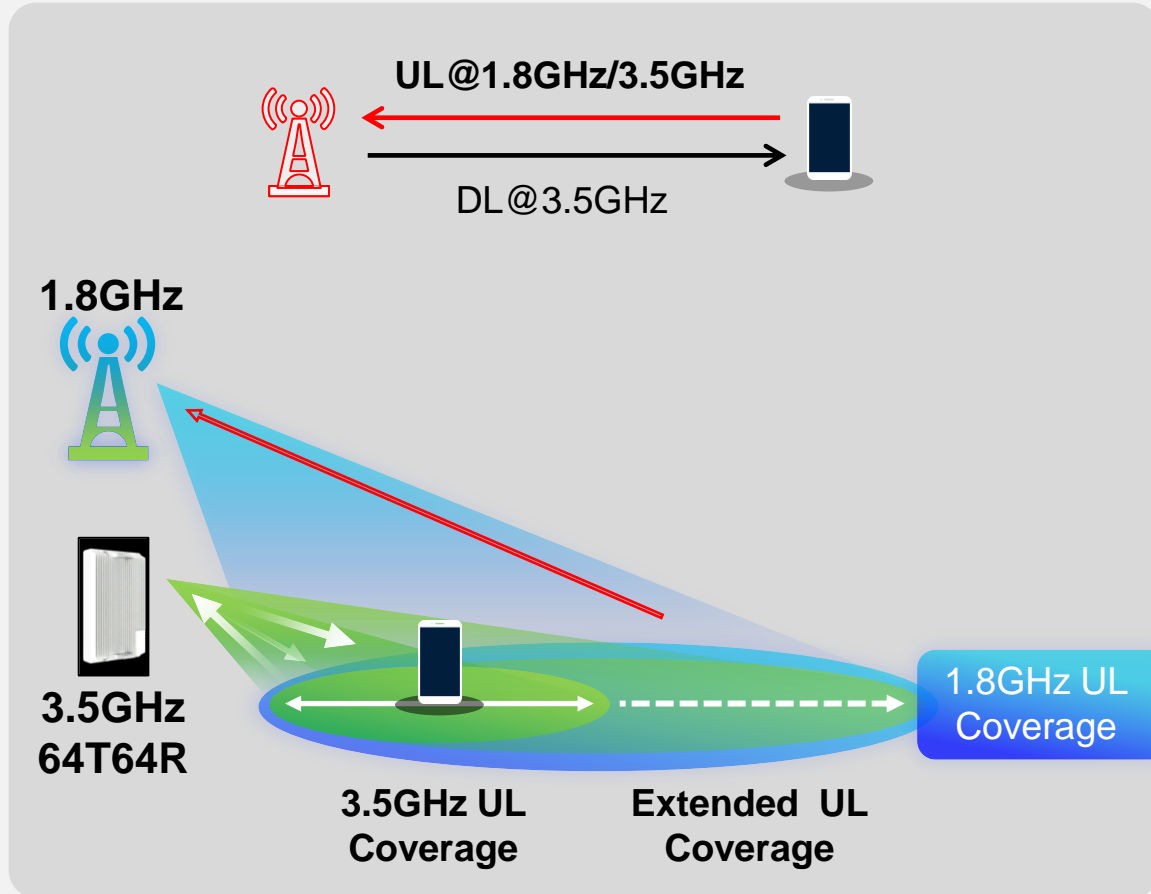




# DL/UL de-coupling (TDD+SUL band operation)

## A new paradigm to guarantee 5G coverage

C-band (TDD 4:1) + Supplementary UL (SUL) band Extends C-band Coverage



TDD + SUL ("DL/UL de-coupling) Adopted by 3GPP R15



### \*Proposed frequency ranges

1920-1980MHz (UL)/3.3-3.8 GHz\*(DL&UL)

1710-1785MHz (UL)/3.3-3.8 GHz\*(DL&UL)

832-862MHz (UL)/3.3-3.8 GHz\*(DL&UL)

880-915MHz (UL)/3.3-3.8 GHz\*(DL&UL)

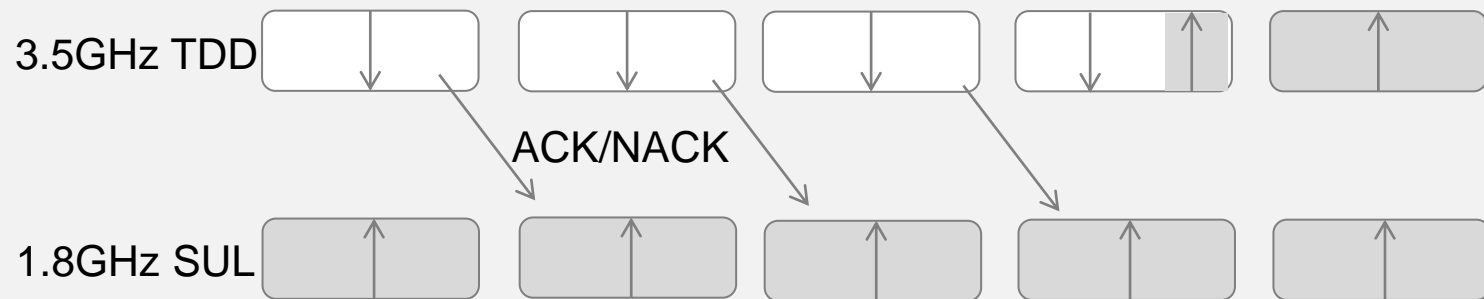
703-748MHz (UL)/3.3-3.8 GHz\* (DL&UL)

- 1800MHz adopted in R15 Phase 1.1
- 700/800/900/2100MHz will be adopted in R15 Phase 1.2

# TDD 4:1 + SUL band operation:

A unified solution for coverage + large data rate + low latency

## TDD 4:1+SUL



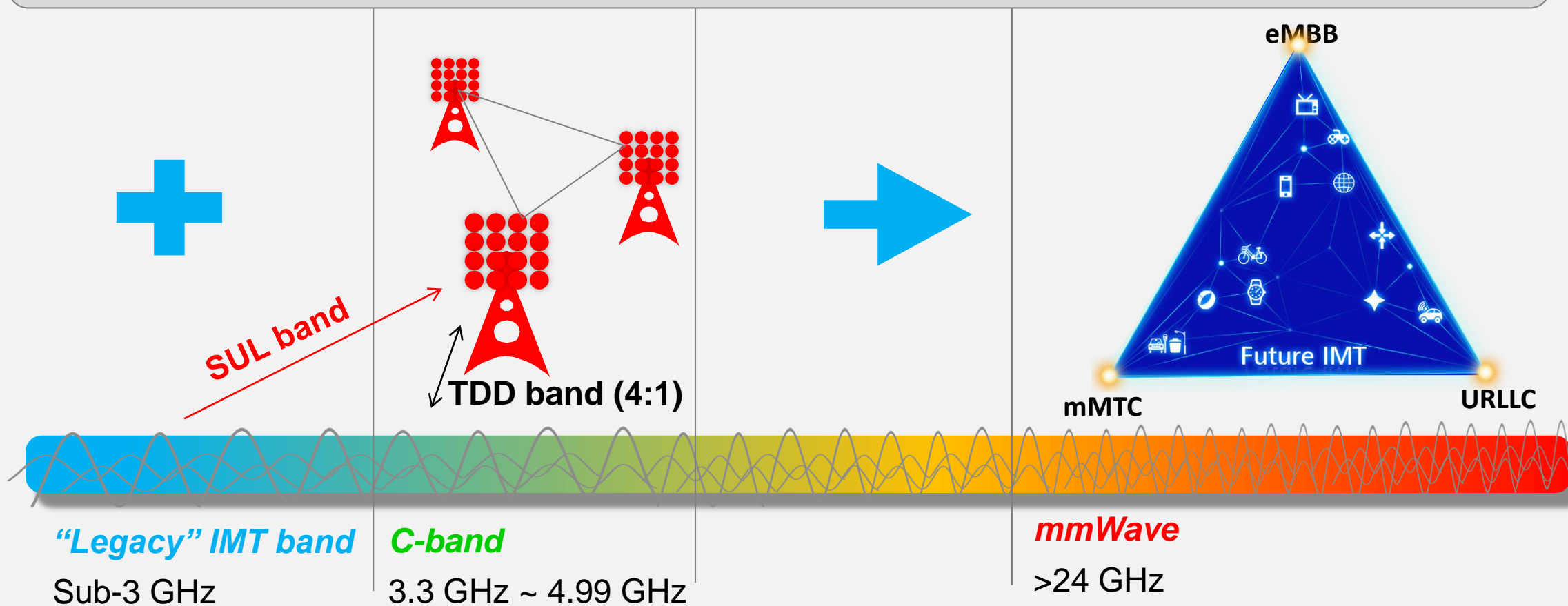
Type	Cell-edge RTT latency	GP overhead
	DL proc. Time 10 sym	GP* 4 sym
TDD (4:1)	<b>3.31ms</b>	2.86%
TDD (1:1)	2.67ms	<b>14.3%</b>
TDD (4:1) +SUL	<b>1.5ms</b>	<b>2.86%</b>

# Summary: When 5G technology fits 5G spectrum

## It opens the way to bring 5G vision into Reality

### NR unified framework

- Frame structure, Numerology, Waveform
- Coding and modulation
- Duplex and spectrum use
- Massive MIMO



# THANK YOU

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