



# **5G** Interview Questions

---

## 50 Questions on Spectrum

Last Updated: 22 Sep 2019



# Background Material

---

- If you are not familiar with the topic, please see the following resources:
  - Radio Frequency, Band and Spectrum ([link](#))
  - 5G Spectrum - Long Version ([link](#))
  - 5G Spectrum - Short Version ([link](#))
  - Non millimeter Wave (mmWave) 5G ([link](#))
  - The Politics of SA vs NSA 5G & 4G Speeds ([link](#))
  - What is "True 5G"? (and "True 4G"?) ([link](#))
- All our videos are available on: <https://www.youtube.com/3G4G5G>

# 01: FR1 & FR2

---

- Question: What's the range of 3GPP defined FR1 & FR2?
- Answer: The current range of FR1 & FR2 defined by 3GPP is:
  - FR1: 410 MHz – 7.125 GHz
  - FR2: 24.25 GHz – 52.6 GHz

# 02: Radio Spectrum

---

- Question: What frequencies does Radio Spectrum cover?
- Answer: The Radio Spectrum is part of spectrum from 3Hz to 3000GHz (3 THz)

# 03: mmWave

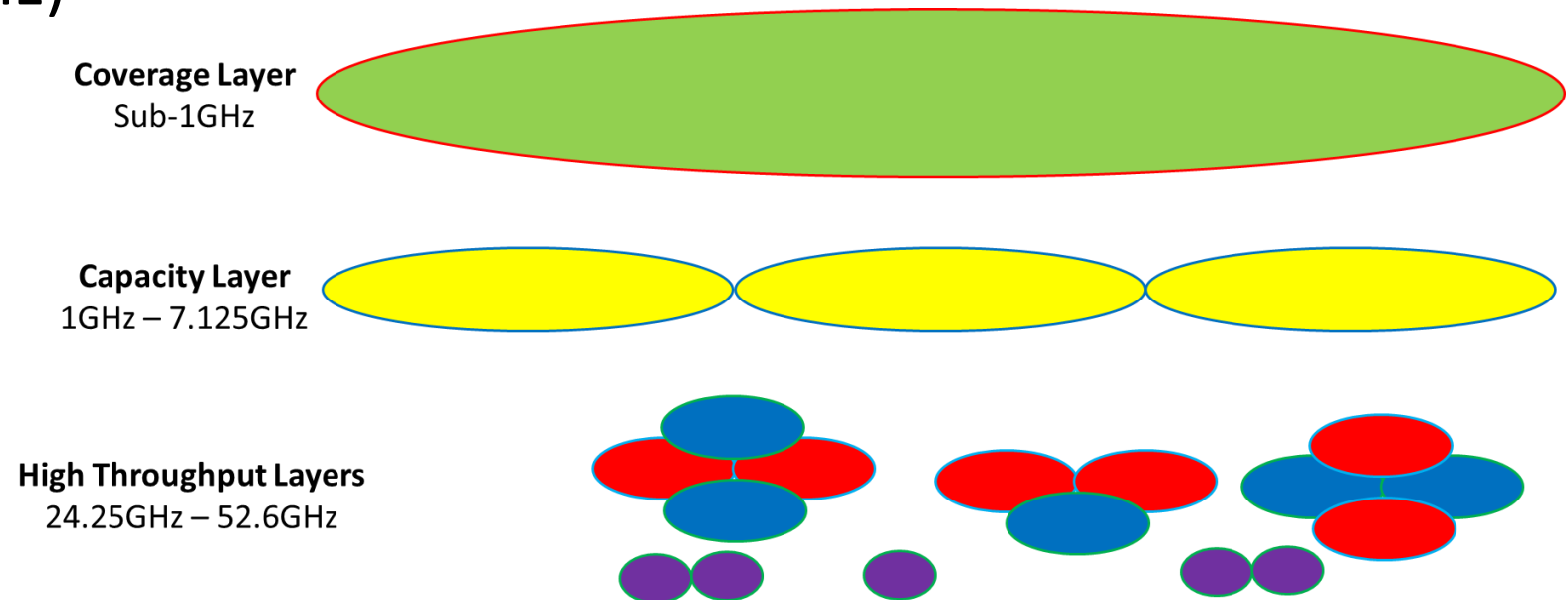
---

- Question: What is millimetre wave spectrum?
- Answer: Technically mmWave starts from 30 GHz but people refer to all frequencies in FR2 as mmWave

# 04: Spectrum Layers

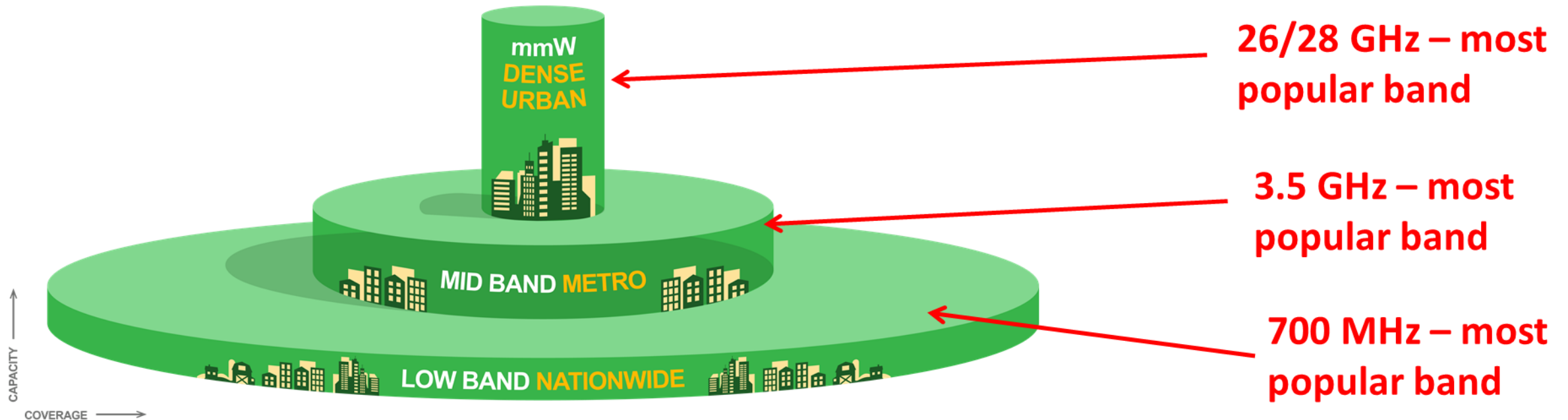
---

- Question: What are the different types of frequencies that operator needs?
- Answer: Coverage layer frequencies (sub-1GHz), Capacity layer frequencies (1 – 7.125 GHz) and High-throughput layer frequencies (24.25 – 52.6 GHz)



# 05: Most Popular Bands

- Question: What are most popular 5G frequency bands?
- Answer: 700 MHz, 3.5 GHz & 28 GHz



# 06: New Spectrum

---

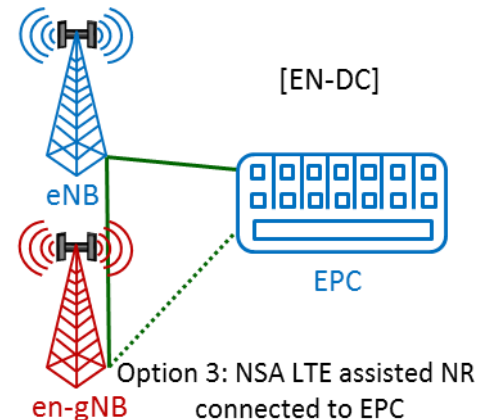
- Question: Does 5G require new spectrum?
- Answer: Not necessarily. Existing 2G/3G/4G spectrum could be re-farmed for 5G



# 07: Minimum Spectrum

---

- Question: What is the minimum amount of spectrum that 5G requires?
- Answer: In theory, for a Non-Standalone 5G, a minimum of 1.4 MHz of 4G and 5 MHz of 5G spectrum is required. So in theory, 6.4 MHz

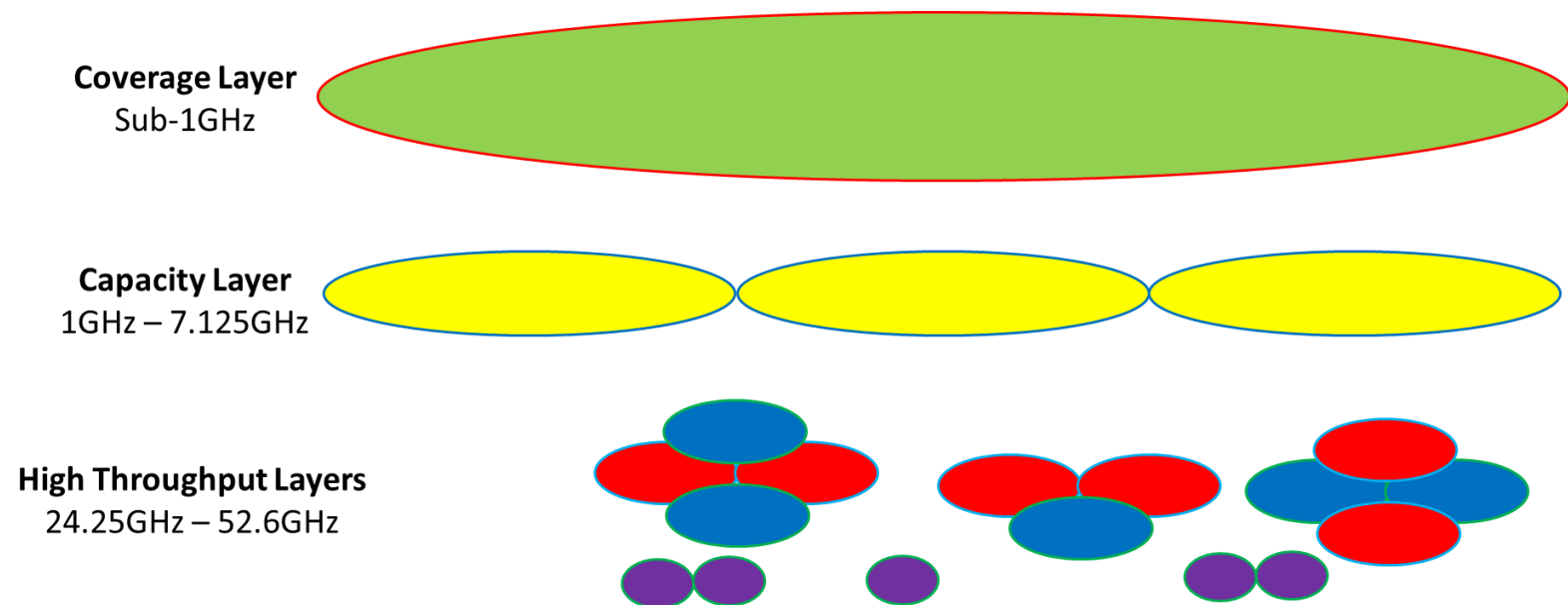


Check out the [5G Terminology presentation](#) to learn about Standalone & Non-Standalone 5G

# 08: Coverage Layer

---

- Question: Is coverage layer frequency a must?
- Answer: For a Non-Standalone 5G, low-band 4G can suffice. For standalone 5G, this will most-likely be required to provide a nationwide 5G



# 09: Existing Spectrum Issues

---

- Question: What problems may be encountered by using existing 2G/3G/4G spectrum for 5G?
- Answer: There may not be enough bandwidth in the existing 2G/3G/4G spectrum to provide a meaningful 5G capacity & throughput. Also, if the existing frequency is used, the current technology will have to be switched off or it will not perform as expected.

# 10: C-band

---

- Question: What is C band?
- Answer: ITU-R defines C band as: 3.4 – 4.2, 4.5 – 4.8, 5.85 – 7.075 GHz.  
For 5G, C band is generally referred to as 3.4 – 4.2 GHz

# 11: Lowest Frequency

---

- Question: What's the lowest frequency of which 5G is being rolled out today?
- Answer: T-Mobile in USA has launched 5G in 600 MHz band. This is probably the lowest frequency 5G in operation today.

# 12: Highest Frequency

---

- Question: What's the highest frequency on which 5G is being rolled out today?
- Answer: Softbank in Japan has won 29.1 – 29.5 GHz spectrum. This is probably the highest frequency in which commercial 5G will be rolled out. In USA, 37 GHz, 39 GHz and 47 GHz will be auctioned very soon (Q4 2019).

# 13: Minimum Bandwidth

- Question: What's the minimum bandwidth of a 5G band
- Answer: The minimum bandwidth for 5G is:
  - FR1: 5 MHz
  - FR2: 50 MHz

Release 15

24

3GPP TS 38.101-1 V15.3.0 (2018-09)

NR Band	NR band / SCS / UE Channel bandwidth												
	SCS kHz	5 MHz	10 <sup>1,2</sup> MHz	15 <sup>2</sup> MHz	20 <sup>2</sup> MHz	25 <sup>2</sup> MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz	90 MHz	100 MHz
n1	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								
	60		Yes	Yes	Yes								
n2	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								
	60		Yes	Yes	Yes								
n3	15	Yes	Yes	Yes	Yes	Yes	Yes						
	30		Yes	Yes	Yes	Yes	Yes						
	60		Yes	Yes	Yes	Yes	Yes						
n5	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								
	60												
n7	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								

Release 15

3GPP TS 38.101-2 V15.3.0 (2018-09)

Table 5.3.5-1: Channel bandwidths for each NR band

Operating band / SCS / UE channel bandwidth					
Operating band	SCS kHz	50 MHz	100 MHz	200 MHz	400 MHz
n257	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes
n258	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes
n260	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes
n261	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes

# 14: Maximum Bandwidth

- Question: What's the maximum bandwidth of a 5G band?
- Answer: The maximum bandwidth for 5G is:
  - FR1: 100 MHz
  - FR2: 400 MHz

Release 15

25

3GPP TS 38.101-1 V15.3.0 (2018-09)

NR Band	NR band / SCS / UE Channel bandwidth												
	SCS kHz	5 MHz	10 <sup>1,2</sup> MHz	15 <sup>2</sup> MHz	20 <sup>2</sup> MHz	25 <sup>2</sup> MHz	30 MHz	40 MHz	50 MHz	60 MHz	80 MHz	90 MHz	100 MHz
n71	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								
	60												
n74	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								
	60		Yes	Yes	Yes								
n75	15	Yes	Yes	Yes	Yes								
	30		Yes	Yes	Yes								
	60		Yes	Yes	Yes								
n76	15	Yes											
	30												
	60												
n77	15		Yes	Yes	Yes			Yes	Yes				
	30		Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	Yes
	60		Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	Yes
n78	15		Yes	Yes	Yes			Yes	Yes				
	30		Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	Yes
	60		Yes	Yes	Yes			Yes	Yes	Yes	Yes	Yes	Yes
n79	15							Yes	Yes				
	30							Yes	Yes	Yes	Yes		Yes
	60							Yes	Yes	Yes	Yes		Yes
n80	15	Yes	Yes	Yes	Yes	Yes	Yes						
	30		Yes	Yes	Yes	Yes	Yes						
	60		Yes	Yes	Yes	Yes	Yes						
	15	Yes	Yes	Yes	Yes								

Release 15

3GPP TS 38.101-2 V15.3.0 (2018-09)

Table 5.3.5-1: Channel bandwidths for each NR band

Operating band / SCS / UE channel bandwidth					
Operating band	SCS kHz	50 MHz	100 MHz	200 MHz	400 MHz
n257	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes
n258	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes
n260	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes
n261	60	Yes	Yes	Yes	
	120	Yes	Yes	Yes	Yes



# 15: 28GHz controversy

- Question: What's this controversy about 28 GHz band?
- Answer: The 28GHz band was not approved by ITU in WRC-15 for 5G study. This implies that no one should be launching 5G on this band as it's a non-approved band. USA, Canada, S.Korea and Japan are launching 5G in 28 GHz band anyways.

Most Popular 5G Frequency Bands

	<1GHz	3GHz	4GHz	5GHz	24-28GHz	37-40GHz	64-71GHz		
	600MHz (2x35MHz) <div><div></div><div></div></div>	2.5GHz (LTE B41) <div><div></div><div></div></div>	3.45-3.55GHz <div><div></div><div></div></div>	3.55-3.7GHz <div><div></div><div></div></div>	3.7-4.2GHz <div><div></div><div></div></div>	5.9-7.1GHz <div><div></div><div></div></div>	24.25-24.45GHz 24.75-25.25GHz <b>27.5-28.35GHz</b> <div><div></div><div></div><div></div></div>	37-37.6GHz 37.6-40GHz 47.2-48.2GHz <div><div></div><div></div><div></div></div>	64-71GHz <div><div></div><div></div></div>
	600MHz (2x35MHz) <div><div></div><div></div></div>		3.55-3.7GHz <div><div></div><div></div></div>				<b>27.5-28.35GHz</b> <div><div></div><div></div></div>	37-37.6GHz 37.6-40GHz <div><div></div><div></div></div>	64-71GHz <div><div></div><div></div></div>
	700MHz (2x30 MHz) <div><div></div><div></div></div>		3.4-3.8GHz <div><div></div><div></div></div>		5.9-6.4GHz <div><div></div><div></div></div>	24.5-27.5GHz <div><div></div><div></div></div>			
	700MHz (2x30 MHz) <div><div></div><div></div></div>		3.4-3.8GHz <div><div></div><div></div></div>			26GHz <div><div></div><div></div></div>			
	700MHz (2x30 MHz) <div><div></div><div></div></div>		3.4-3.8GHz <div><div></div><div></div></div>			26GHz <div><div></div><div></div></div>			
	700MHz (2x30 MHz) <div><div></div><div></div></div>		3.46-3.8GHz <div><div></div><div></div></div>			26GHz <div><div></div><div></div></div>			
	700MHz (2x30 MHz) <div><div></div><div></div></div>		3.6-3.8GHz <div><div></div><div></div></div>			26.5-27.5GHz <div><div></div><div></div></div>			
			3.3-3.6GHz <div><div></div><div></div></div>	4.8-5GHz <div><div></div><div></div></div>		24.5-27.5GHz <div><div></div><div></div></div>	37.5-42.5GHz <div><div></div><div></div></div>		
			3.4-3.7GHz <div><div></div><div></div></div>			26.5- <b>29.5GHz</b> <div><div></div><div></div></div>			
			3.6-4.2GHz <div><div></div><div></div></div>	4.4-4.9GHz <div><div></div><div></div></div>		26.5- <b>28.5GHz</b> <div><div></div><div></div></div>			
			3.4-3.7GHz <div><div></div><div></div></div>			24.25-27.5GHz <div><div></div><div></div></div>	39GHz <div><div></div><div></div></div>		

Source: Qualcomm

Red highlights frequencies not approved for ITU study

New 5G band  
— Licensed  
— Unlicensed/shared  
— Existing band

©3G4G

3G4G

# 16: 5GHz 5G

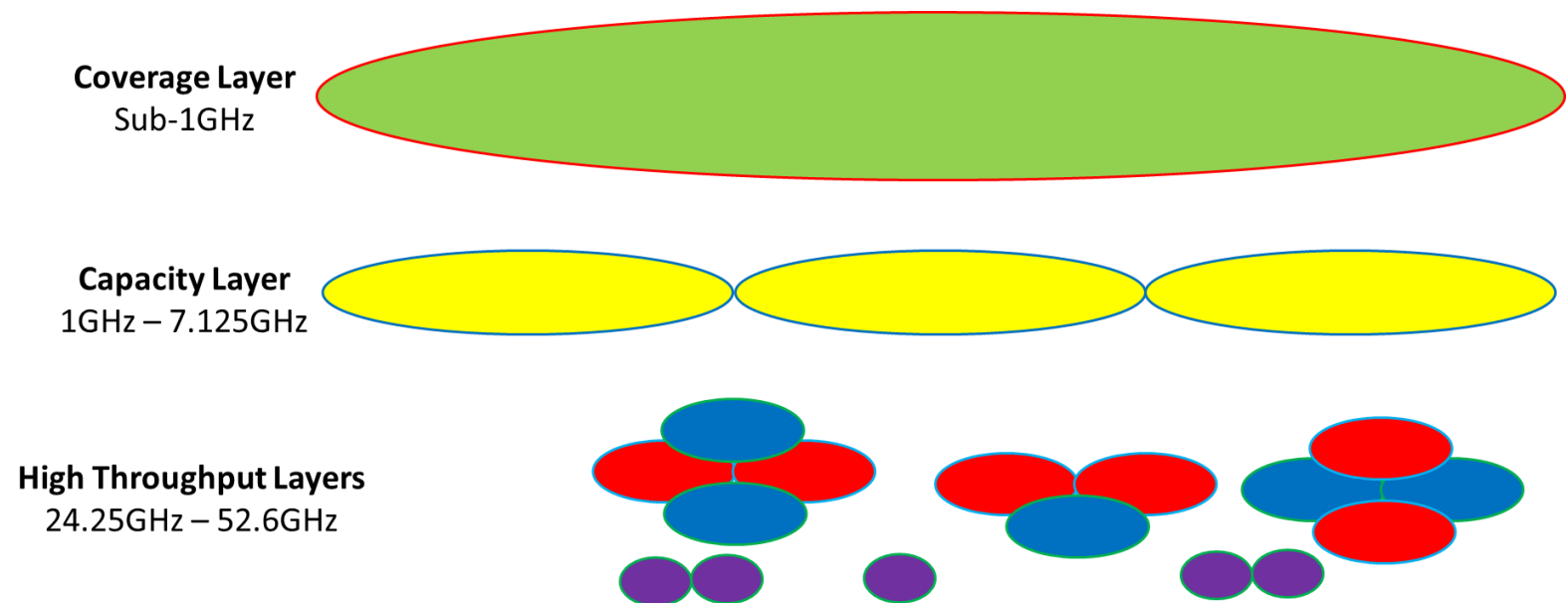
---

- Question: Can 5GHz license-exempt band be used for 5G?
- Answer: At present (Release-15), no. In future 5G can probably use the 5GHz band for supplemental uplink/downlink.

# 17: Nationwide 5G

---

- Question: How do you roll out nationwide 5G?
- Answer: In any coverage layer frequency. T-Mobile USA is planning to rollout 5G in 600 MHz band to get a nationwide 5G.



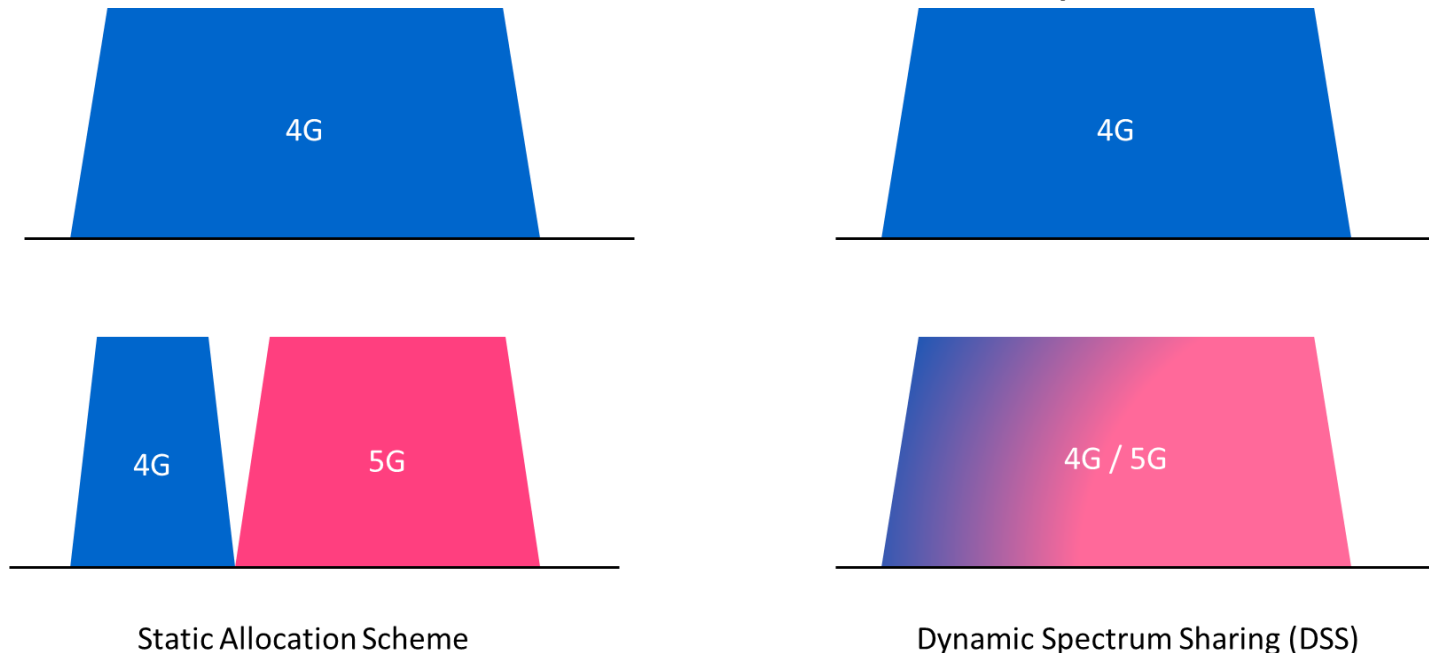
# 18: Sprint 5G

- Question: Why is Sprint's 5G special?
- Answer: Sprint in USA has loads of 2.5 GHz spectrum (band 41) available. It's using part of this band for 4G and part for 5G. They also have same antennas transmitting both 4G & 5G.



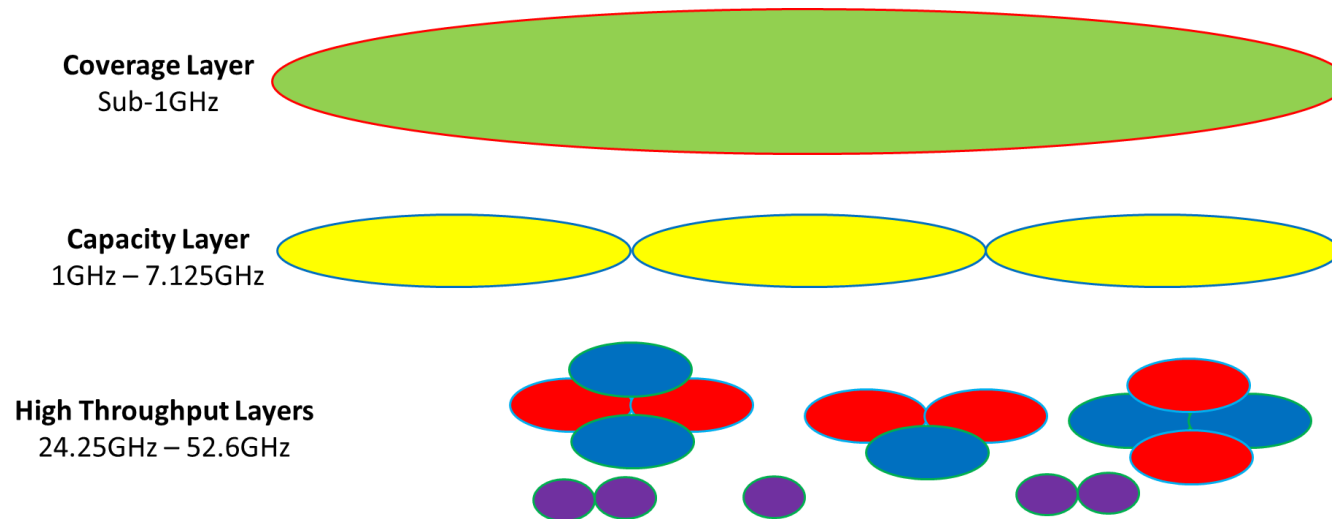
# 19: DSS

- Question: What is DSS?
- Answer: In Static Spectrum Re-farming Scheme, the spectrum has to be divided statically in advance. This would mean that 4G would become congested while 5G spectrum wasn't efficiently used. In Dynamic Spectrum Sharing (DSS), the spectrum is allocated to both 4G & 5G by the scheduler intelligently, depending on the requirements. This is much more efficient use of Spectrum



# 20: Ideal Spectrum

- Question: Which country has got most balanced 5G spectrum?
- Answer: Ideally the operators in a country should get access to coverage, capacity and high throughput layer at the same time. This ensures they can plan their rollout efficiently. Italy is one such country where operators have these three bands.



Band	Lot	Spectrum [MHz]	Winner	Price [€]	+% vs reserve price
700 MHz FDD	700_R	2x10	Iliad	676.472.792	0%
	700_FDD	2x5	Vodafone	345.000.000	2%
	700_FDD	2x5	Vodafone	338.236.396	0%
	700_FDD	2x5	TIM	340.100.000	0,6%
	700_FDD	2x5	TIM	340.100.000	0,6%
		2x30		2.039.909.188	0,52%
3.7 GHz	3700_C1	80	TIM	1.694.000.000	970%
	3700_C2	80	Vodafone	1.685.000.000	962%
	3700_C3	20	Wind Tre	483.920.000	1120%
	3700_C4	20	Iliad	483.900.000	1120%
		200		4.346.820.000	997%
26 GHz	26G	200	TIM	33.020.000	1,3%
	26G	200	Iliad	32.900.000	1,0%
	26G	200	Fastweb	32.600.000	0,04%
	26G	200	Wind Tre	32.586.535	0%
	26G	200	Vodafone	32.586.535	0%
		1000		163.693.070	0,5%
ALL		1260		6.550.422.258	162,0%

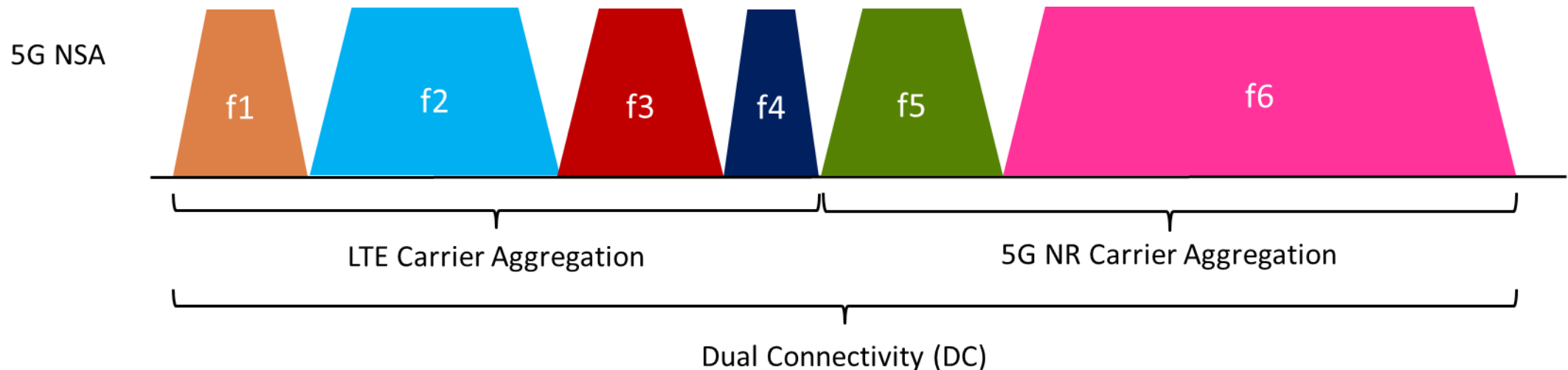
# 21: 5G CA

---

- Question: Can you do carrier aggregation with 5G?
- Answer: While LTE-A supported up to 5 Component Carriers (CC), each with a max of 20 MHz for Carrier Aggregation, LTE-A Pro supports 32 CCs with a max of 20 MHz for Carrier Aggregation. On the other hand, 5G NR supports up to 16 CCs of max 400 MHz bandwidth for each component carrier.

# 22: LTE-5G CA

- Question: Can you aggregate LTE & 5G?
- Answer: Dual connectivity in Non-Standalone 5G allows combining of carrier aggregated LTE and carrier aggregated NR spectrum but carrier aggregation of LTE-5G carriers are not allowed.





# 23: Dual-Connectivity

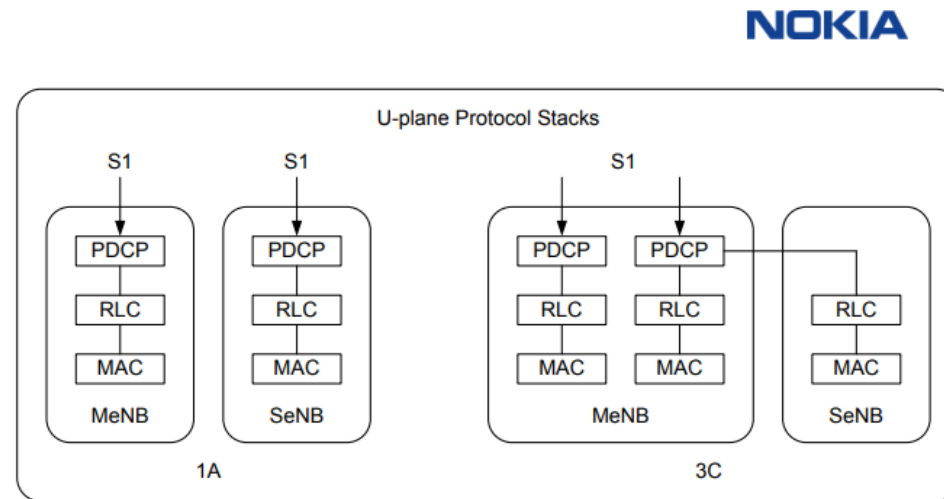
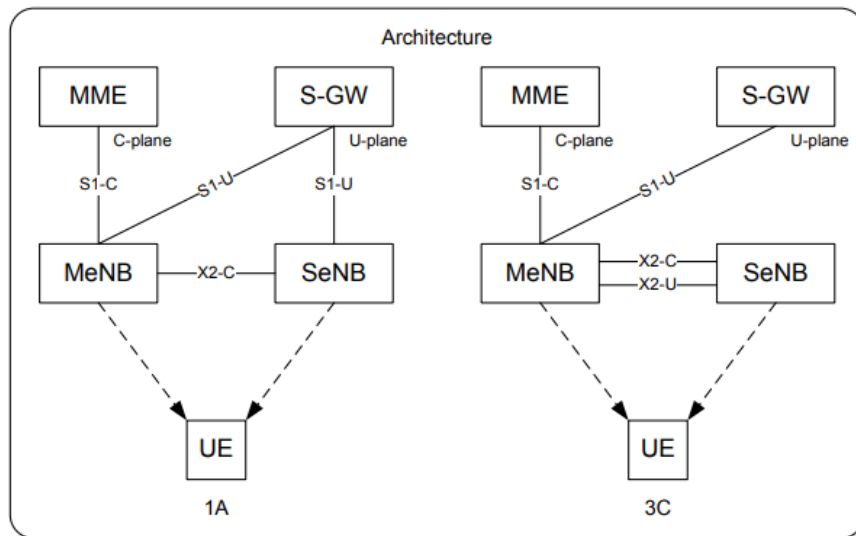
---

- Question: What is dual connectivity?
- Answer: Dual Connectivity (DC) was introduced in 3GPP to allow a UE to simultaneously transmit and receive data on multiple component carriers from two cell groups via master eNB (MeNB) and secondary eNB (SeNB). DC can increase user throughput, provide mobility robustness, and support load-balancing among eNBs.

Continued...

# 23: Dual-Connectivity - Continued

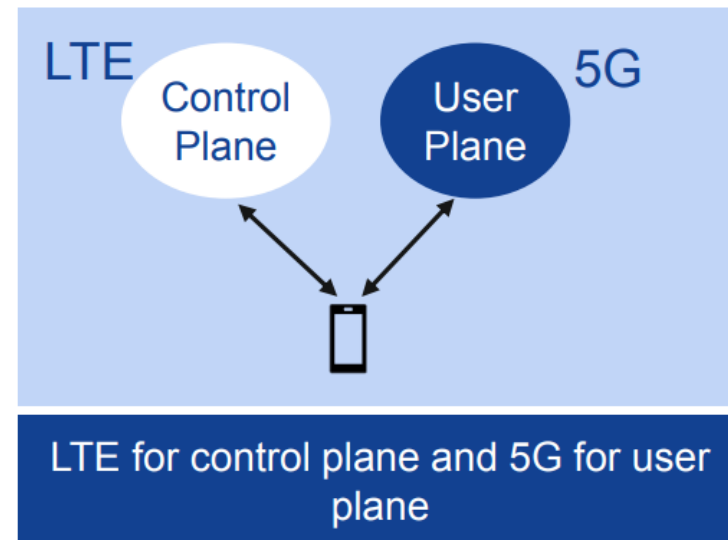
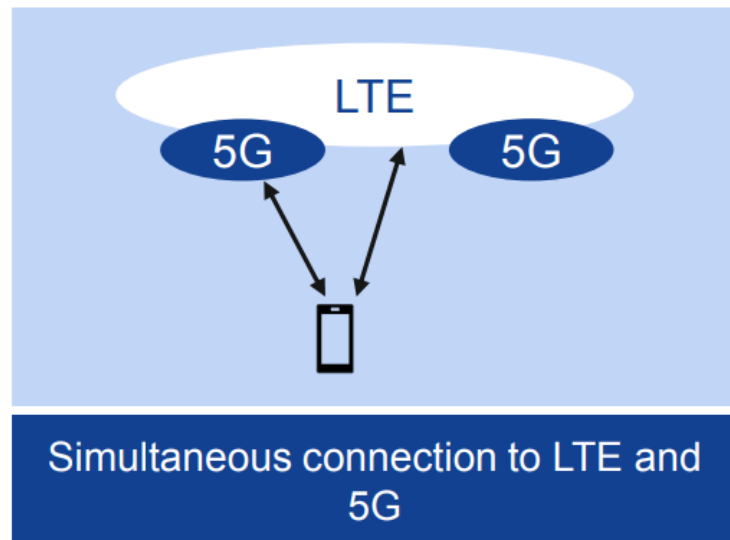
- While there is only one C-plane S1-MME connection per UE
  - RRC connection via MeNB only, SeNB connection is controlled through MeNB
- There are two DC user-plane architecture options are supported:
  - 1A – S1-U termination at MeNB and SeNB (analogous to carrier aggregation)
  - 3C – S1-U termination at MeNB, bearer split in RAN (analogous to off-loading)



# 23: Dual-Connectivity - Continued

In case of LTE – NR Dual Connectivity

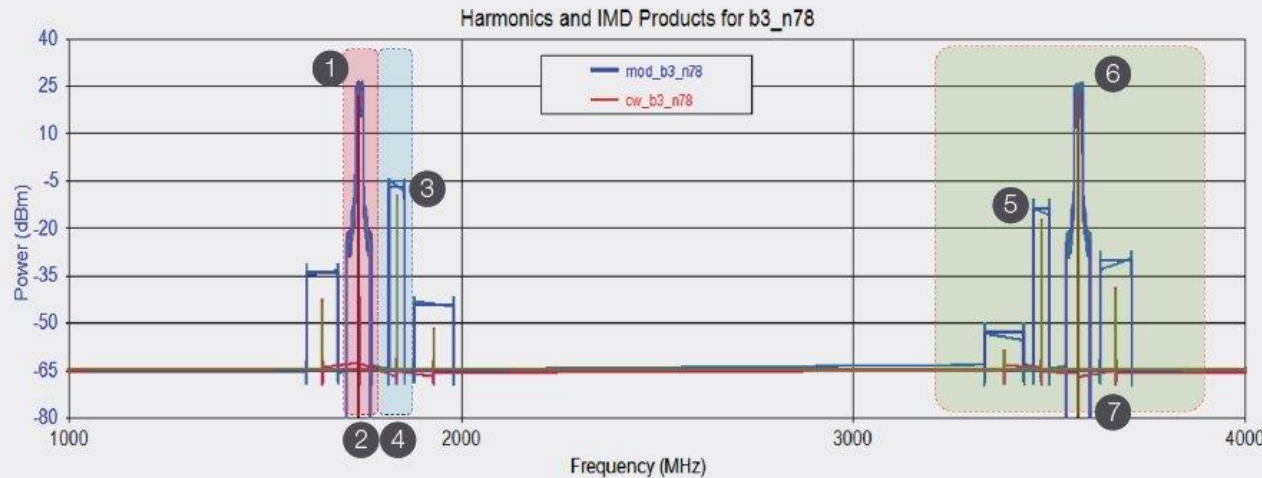
- Stand-alone NR - UE accesses standalone NR carrier and may not be connected to an LTE carrier.
- Non stand-alone NR (dual connectivity of LTE and NR) - UE accesses LTE PCell, then is configured by dual connectivity to also operate on NR
  - UE may be simultaneously connected to LTE and NR, or to LTE for control plane and NR for user plane



**NOKIA**

# 24: Interference

- Question: Is there interference between LTE & 5G bands
- Answer: With so many different bands in use, there is a small possibility of interference between them. A [recent whitepaper from Keysight](#) points out that the 5G Uplink transmission in 3.5 GHz band might significantly interfere with 4G in the 1.8 GHz band in downlink direction. Maybe bad news, especially in Europe, where these are heavily used.

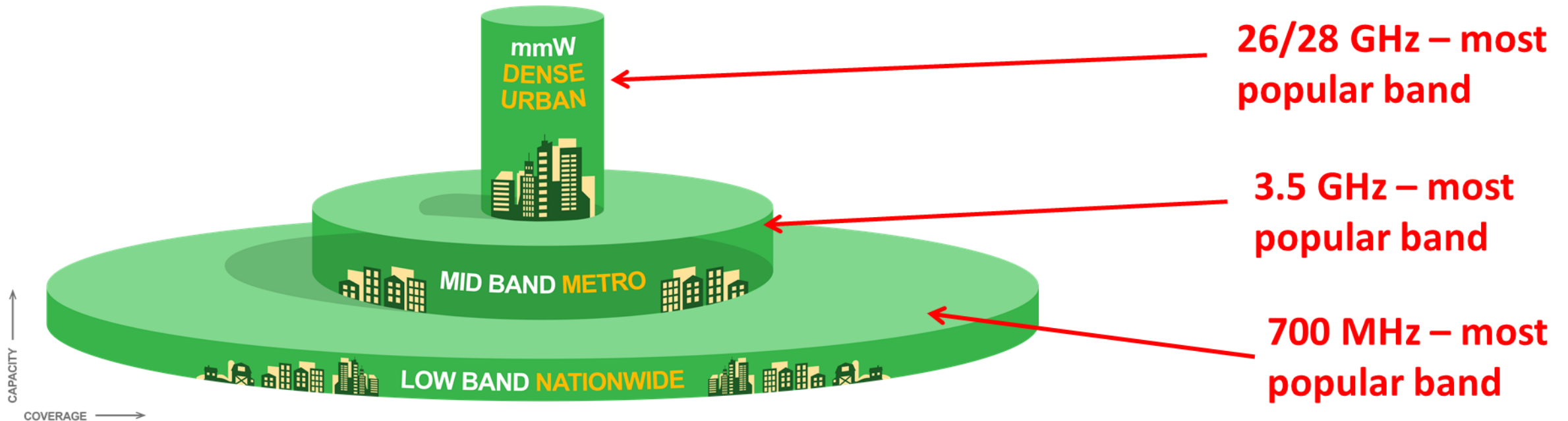


1. b3 uplink signal 1740 MHz
2. b3 uplink band 1710 MHz ~ 1785 MHz
3. IMD's landing on b3 receive frequency 1835 MHz
4. b3 downlink band 1805 MHz ~ 1880 MHz
5. IMD product at 3480 MHz, self-interference for the TDD band?
6. n78 TDD band 3300 MHz ~ 3800 MHz
7. n78 uplink signal 3575 MHz

Figure 3a: Intermodulation and harmonic analysis with two modulated signals at 1740 MHz and 3575 MHz.

# 25: Most popular bands for all Gs

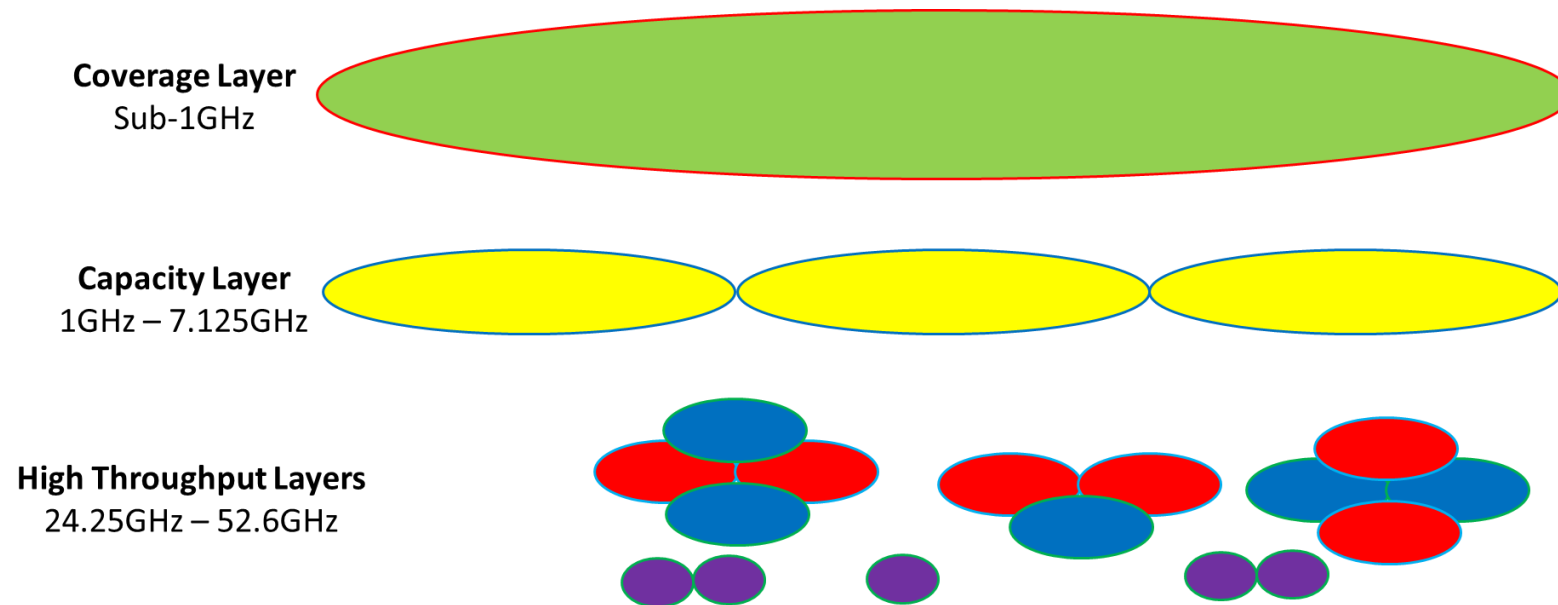
- Question: What are most popular bands worldwide for 2G, 3G, 4G & 5G?
- Answer: Most popular band for:
  - 2G is 900 MHz/1800 MHz,
  - 3G is 2100 MHz (2.1 GHz), which is Band 1.
  - 4G is 1800 MHz (mostly re-farmed from 2G), which is band 3 or 2.6 GHz, band 7.
  - For 5G we have already discussed, as shown in the picture below.



# 26: 60 GHz Spectrum

---

- Question: Can 60 GHz WiGig spectrum be used for 5G?
- Answer: At the moment, frequency range FR2 stops at 52.6 GHz so 60 GHz is beyond the usable 5G FR2 spectrum limit.



# 27: Most-popular Backhaul Bands

- Question: What are most popular bands used for Backhaul?
- Answer: [GSMA Mobile Backhaul Options](#) whitepaper listed Microwave, V-band and E-band as the most popular backhaul bands.

Table 1

## Mobile Backhaul Technology Trade-Offs

Wireless vs Fixed vs Satellite

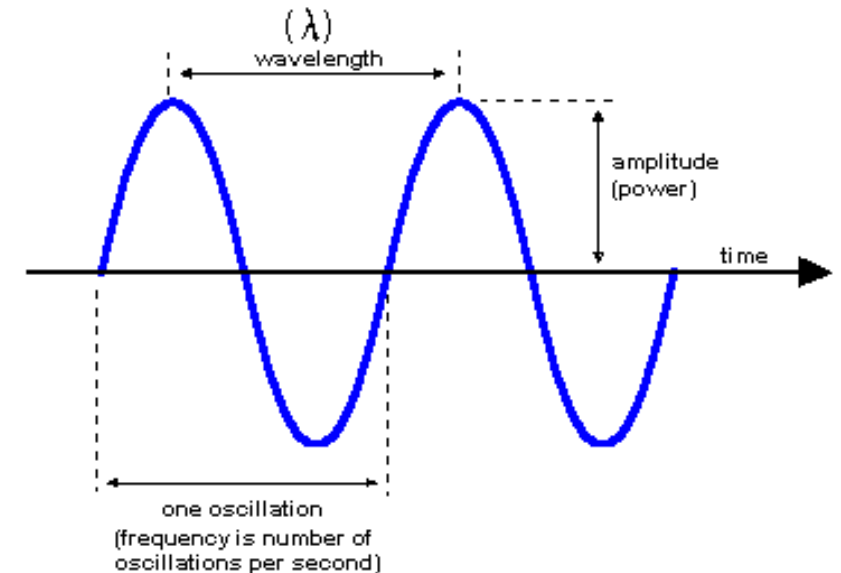
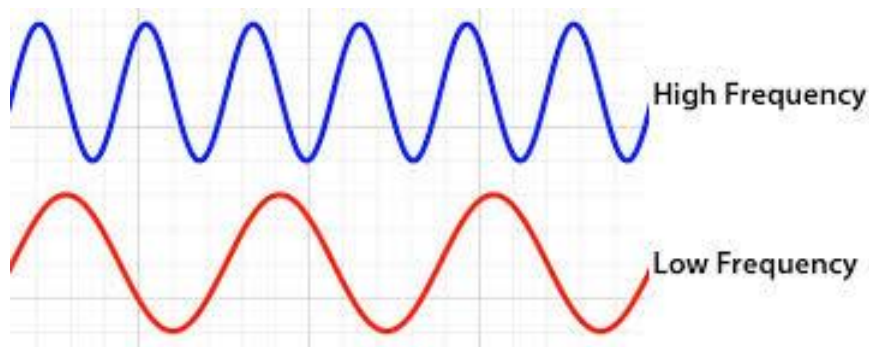
Segment	Microwave (7-40 GHz)	V-Band (60 GHz)	E-Band (70/80 GHz)	Fiber-optic	Copper (Bonded)	Satellite
Future-Proof Available Bandwidth	Medium	High	High	High	Very Low	Low
Deployment Cost	Low	Low	Low	Medium	Medium/High	High
Suitability for Heterogeneous Networks	Outdoor Cell-Site/Access Network	Outdoor Cell-Site/Access Network	Outdoor Cell-Site/Access Network	Outdoor Cell-Site/Access Network	Indoor Access Network	Rural only
Support for Mesh/Ring Topology	Yes	Yes	Yes	Yes where available	Indoors	Yes
Interference Immunity	Medium	High	High	Very High	Very High	Medium
Range (Km)	5-30, ++	1-	-3	<80	<15	Unlimited
Time to Deploy	Weeks	Days	Days	Months	Months	Months
License Required	Yes	Light License/ Unlicensed	Licensed/ Light License	No	No	No

Note: Shading indicates preferred choice for 5G mobile backhaul.

Source: ABI Research

# 28: Wavelength

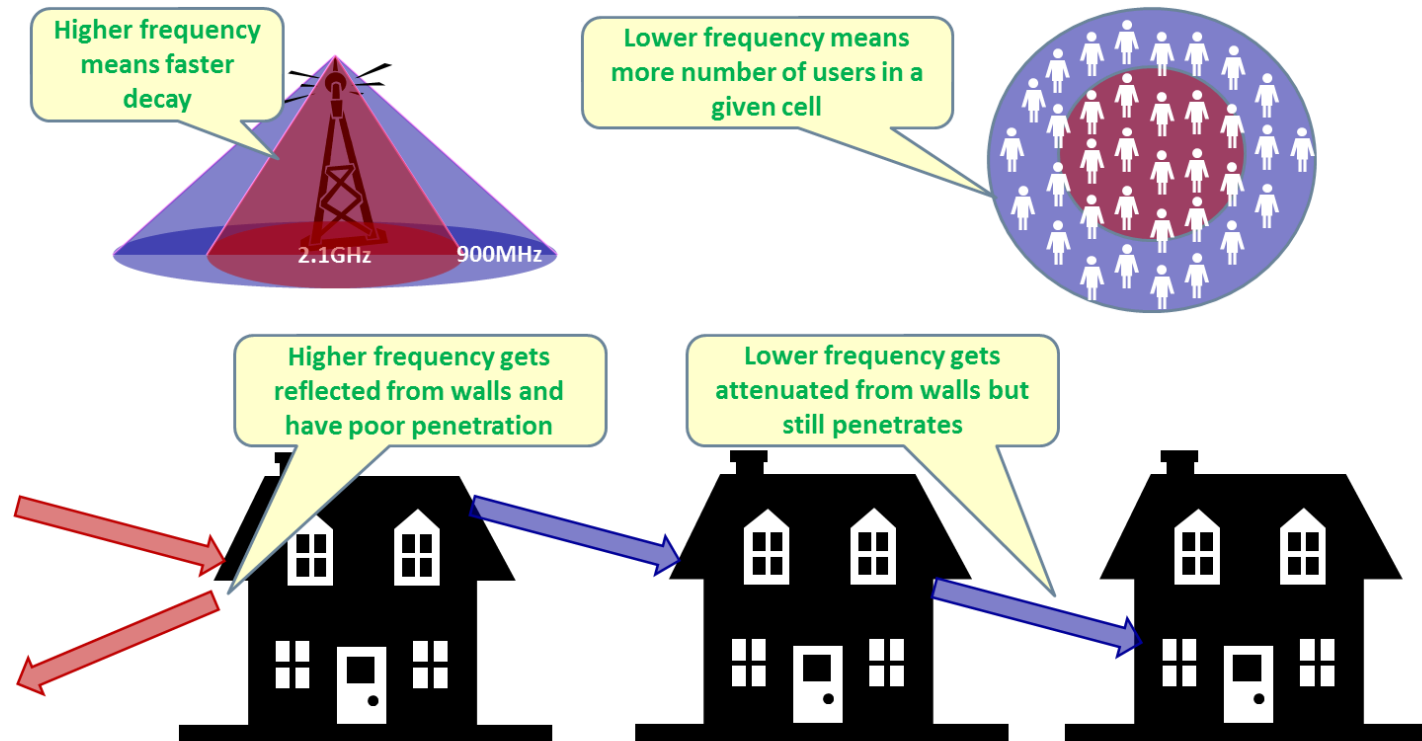
- Question: How is a wavelength defined?
- Answer: Wavelength (generally written as Greek letter Lambda ' $\lambda$ ') is the distance between similar points on two back-to-back waves.
  - Its calculated  $\lambda = c / f$ , where  $c$  is the speed of light, 299,792,458 m/s
  - For 1MHz,  $\lambda = 299.792458$  metres or roughly 300 m
  - For 1GHz,  $\lambda$  is roughly 30cm





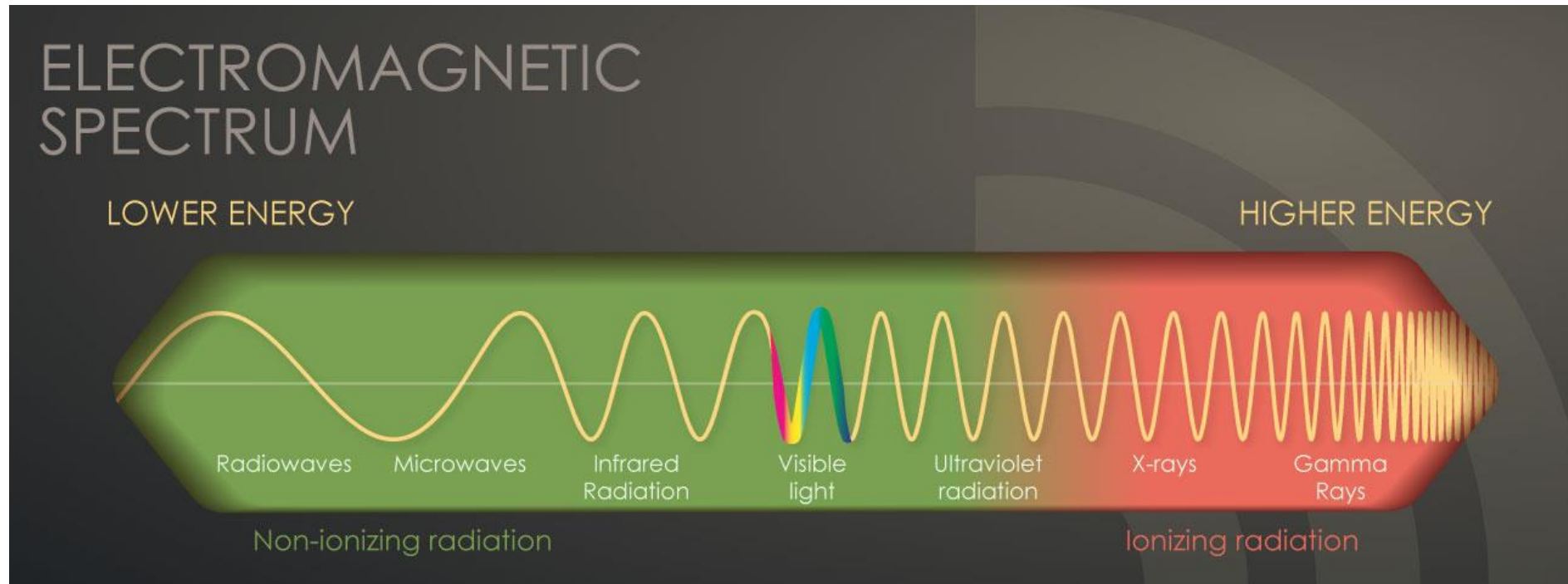
# 29: Frequency selection

- Question: Is low frequencies better or higher frequencies?
- Answer: Well, it depends. Low frequencies is good for providing coverage while higher frequencies are good for providing capacity and higher throughput



# 30: Dangers of mmWave

- Question: Why is mmWave dangerous?
- Answer: It's not! Millimetre waves are not dangerous. Ionizing radiation is dangerous to humans and it occurs at far far higher frequency. Even the light from sun, bulbs, LEDs, etc occurs at much higher frequencies than 5G but is not dangerous.



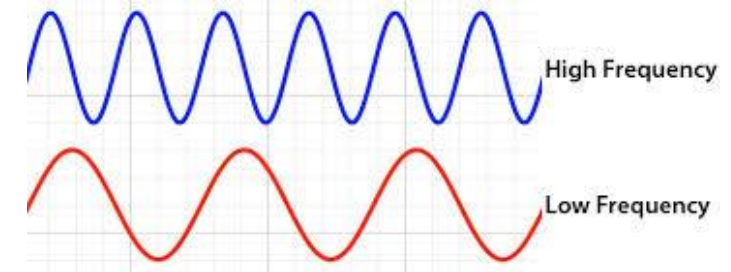
# 31: Spectrum Band

---

- Question: How do you define spectrum band
- Answer: A Spectrum (plural 'spectra' or 'spectrums') is used to classify something on a scale between two extreme points. The Radio Frequency Spectrum is part of spectrum from 3Hz to 3000GHz (3 THz). Bands are group of frequencies, defined to make it easier to remember.

# 32: mmWave Distance

---



- Question: Why doesn't mmWave travel far
- Answer: As we saw earlier, higher frequencies means shorter wavelengths. In higher frequencies, energy is lost due to collisions between the particles in the medium in which it travels and the photons of the electromagnetic wave. This increases when frequency increases as compared with low frequency signals and this can be seen through the above sample picture. So higher Energy is lost for higher frequencies or shorter wavelengths. mmWave frequencies are much higher, implying much more loss of energy

# 32: mmWave Distance – continued...

A comparison of pathloss for 2.6GHz, 28 GHz and 39 GHz is shown in the table below. As can be seen, the pathloss increases at higher frequencies.

TABLE II  
CALCULATION AND COMPARISON OF PATH LOSS.

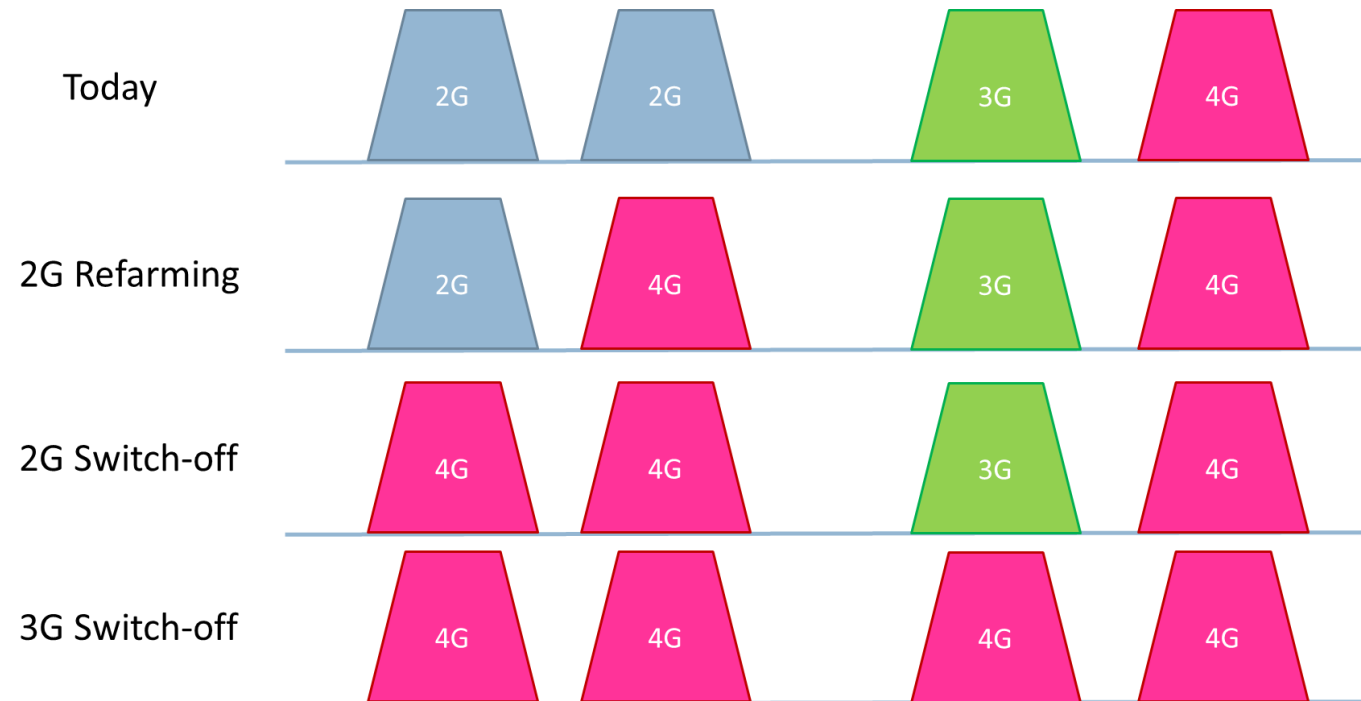
Frequency/distance	Path loss of popular deployment scenarios (dB)					
	UMa-LOS	UMa-NLOS	UMi-Street Canyon-LOS	UMi-Street Canyon-NLOS	UMi-Street Open-LOS	UMi-Street Open-NLOS
LTE Band 41 2.6 GHz, d=100m	84.8	107.5	83.4	112.7	81.9	105.6
28 GHz, d=100m	105.5	128.2	104.1	133.4	102.6	126.3
39 GHz, d=100m	108.4	131.1	107	136.3	105.5	129.2
39 GHz, d=100m, rain and oxygen loss <sup>1</sup>	109.4	132.1	108	137.3	106.5	139.2
LTE Band 41 2.6 GHz, d=1 km	104.9	137.5	103.2	144.6	100.4	134.5
28 GHz, d=1 km	125.5	158.2	123.9	165.3	121.1	155.2
39 GHz, d=1 km	128.4	161.1	126.8	168.2	124	158.1
39 GHz, d=1 km, rain and oxygen loss <sup>1</sup>	136.5	169.2	134.9	176.3	132.1	166.2

<sup>1</sup> Heavy rain of 25mm/h model is used

[Source](#)

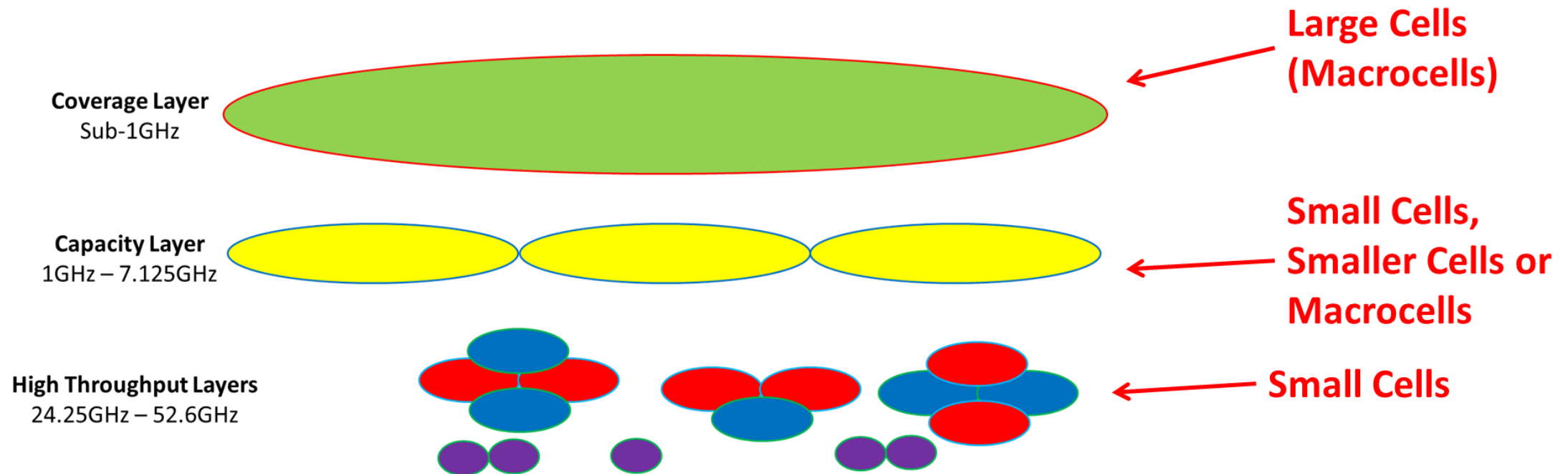
# 33: Re-farming

- Question: What is spectrum re-farming?
- Answer: When spectrum used for existing technologies are used for newer technologies, this is called re-farming of spectrum. If all the frequency from an existing technology is refarmed, the existing technology is switched off. This can be understood by looking at example below.



# 34: Small Cell Frequencies

- Question: What spectrum will 5G small cells use?
- Answer: Small cells can be used for capacity layer as well as high-throughput layers.



# 35: URLLC Spectrum

---

- Question: What spectrum does URLLC require?
- Answer: URLLC feature is spectrum independent. Having said that, it is mostly characterised by low data rates along with very low latency and extremely high reliability. For generic URLLC applications that will need mobility, coverage layer spectrum will have a big role to play, followed by capacity layer spectrum.



# 36: mMTC Spectrum

---

- Question: What spectrum will mMTC use?
- Answer: The requirements for 5G requires a support for very high number of M2M / MTC / IoT devices. These devices do not transmit a lot of data but require a near ubiquitous connectivity. Coverage layer spectrum, sub-1GHz has a big role to play in case of mMTC.

# 37: eMBB Bandwidth

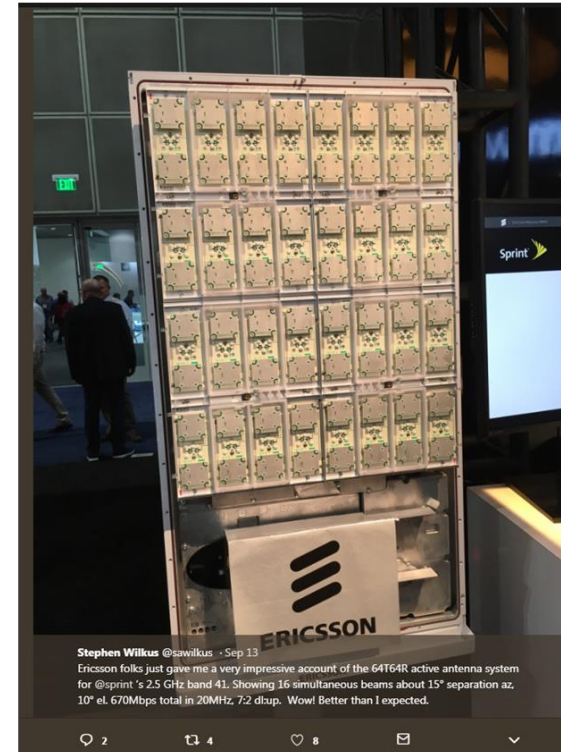
---

- Question: What is a reasonable amount of bandwidth for rolling out eMBB services?
- Answer: For reasonable speeds, in case of NSA 5G networks, a combined 50 MHz spectrum of 4G & 5G is a reasonable amount. In case of SA 5G, 50 MHz of carrier aggregated 5G spectrum is a reasonable amount. The higher the amount of bandwidth, the better the throughput and QoE for the end user.

# 38: mMIMO Spectrum

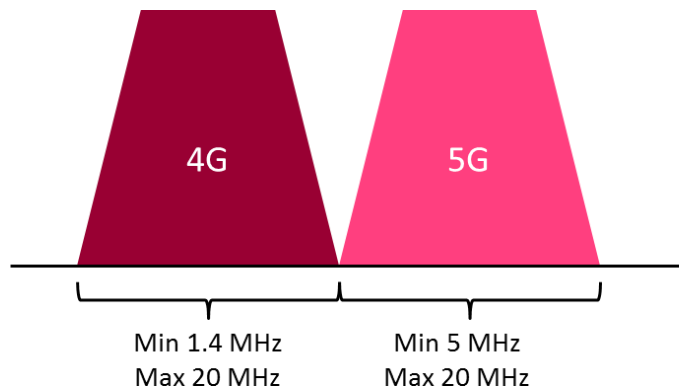
- Question: At what frequency onwards can you start using mMIMO?
- Answer: You can start using massive MIMO from above 2GHz ideally. This is because the antenna sizes are large for below 2GHz, especially for massive MIMO. Sprint in US is using mMIMO for their 2.5 GHz 4G & 5G rollout.

Picture: Sprint shows off 64T64R active antennas (Massive MIMO)

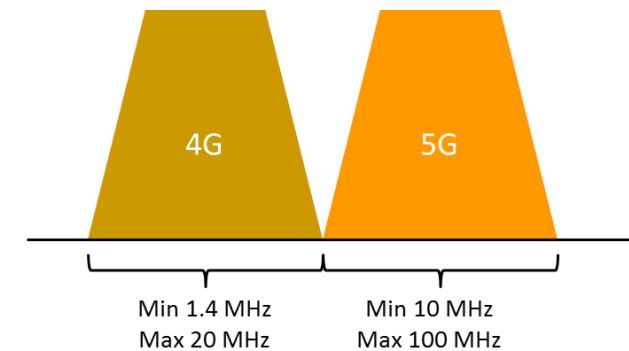


# 39: 5G & 4G same spectrum

- Question: Can 5G & 4G exist in same spectrum?
- Answer: Yes, of course. T-Mobile in USA has launched 4G in 600 MHz (Band 71) and is launching 5G in the same band. Sprint, another US operator is doing the same with 2.5 GHz band (Band 41).



NR band / SCS / UE Channel bandwidth									
NR Band	SCS kHz	5 MHz	10 <sup>1,2</sup> MHz	15 <sup>2</sup> MHz	20 <sup>2</sup> MHz	25 <sup>2</sup> MHz	30 MHz	40 MHz	50 MHz
n71	15	Yes	Yes	Yes	Yes				
	30		Yes	Yes	Yes				
	60								



NR band / SCS / UE Channel bandwidth									
NR Band	SCS kHz	5 MHz	10 <sup>1,2</sup> MHz	15 <sup>2</sup> MHz	20 <sup>2</sup> MHz	25 <sup>2</sup> MHz	30 MHz	40 MHz	50 MHz
n41	15		Yes	Yes	Yes			Yes	Yes
	30		Yes	Yes	Yes			Yes	Yes
	60		Yes	Yes	Yes			Yes	Yes

# 40: Terahertz (THz) Frequencies

---

- Question: What are Terahertz (THz) Frequencies?
- Answer: Just as we use the phrase 'kilo' to mean  $10^3$ , so we use the term 'giga' to mean  $10^9$  and the term 'tera' to mean  $10^{12}$ . "Hertz (Hz)" is a unit of a physical quantity called frequency. It indicates how many times alternating electric signals and electromagnetic waves change polarity (plus and minus) per second. That is, one terahertz ( $1 \text{ THz} = 1,000 \text{ GHz}$ ) is the frequency of the electromagnetic wave changing the polarity by  $1 \times 10^{12}$  times per second. In general, a terahertz wave often indicates an electromagnetic wave of 0.3 THz to 3 THz.

In Beyond-5G research, any frequency above 100 GHz is being called as THz.

# 41: Contiguous Spectrum

---

- Question: Does 5G require contiguous spectrum in a band?
- Answer: Not necessarily. Carrier Aggregation could be used but having a contiguous spectrum will help reduce signalling and will be a much more efficient use of spectrum.

# 42: 100 MHz Bandwidth

---

- Question: Is 100 MHz bandwidth required to roll out true 5G?
- Answer: Some operators are emphasizing that 100 MHz bandwidth is required to roll out real 5G but there is no such requirement. The minimum 100 MHz bandwidth is a requirement set for the minimum technical performance of IMT-2020 candidate radio interface technologies. That is to say that this is the minimum as to what the 5G standards defined by 3GPP must support, not the actual operator 5G deployment

For more information, watch our Opinion piece [here](#).

# 43: FWA Spectrum

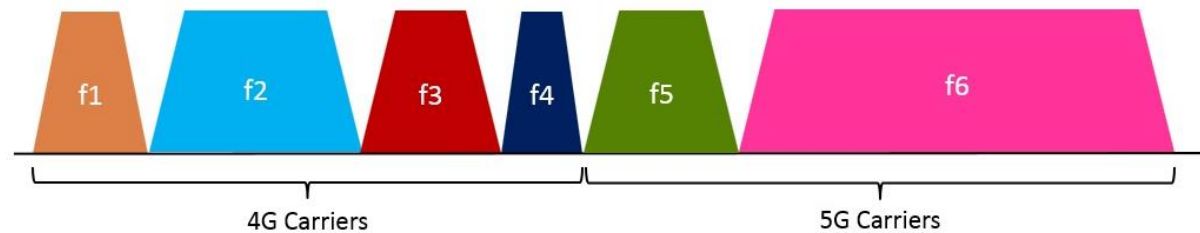
---

- Question: What spectrum is required to roll out FWA?
- Answer: Ideally you need large amount of bandwidth to roll out Fixed-Wireless Access network. In some cases, operators are using the Capacity layer spectrum while in other cases, operators are using High-Throughput Layer Spectrum. In both the cases, Massive MIMO and Beamforming can increase capacity significantly



# 44: 5G Impact on 4G Speeds

- Question: Will 5G reduce 4G speeds?
- Answer: There are quite a few debates on this subject. Most operators insist that 5G will not impact 4G speeds but when 5G SA network is rolled out, some 4G spectrum will have to be re-farmed for 5G. Also in case of 5G NSA, 4G carriers are being used along with the 5G carriers to increase throughput. Watch our Opinion piece [here](#).



5G NSA Speeds = 4G Speeds + 5G Coverage/Capacity Layer Speeds + 5G mmWave Speeds



5G SA Speeds = 5G Coverage/Capacity Layer Speeds + 5G mmWave Speeds

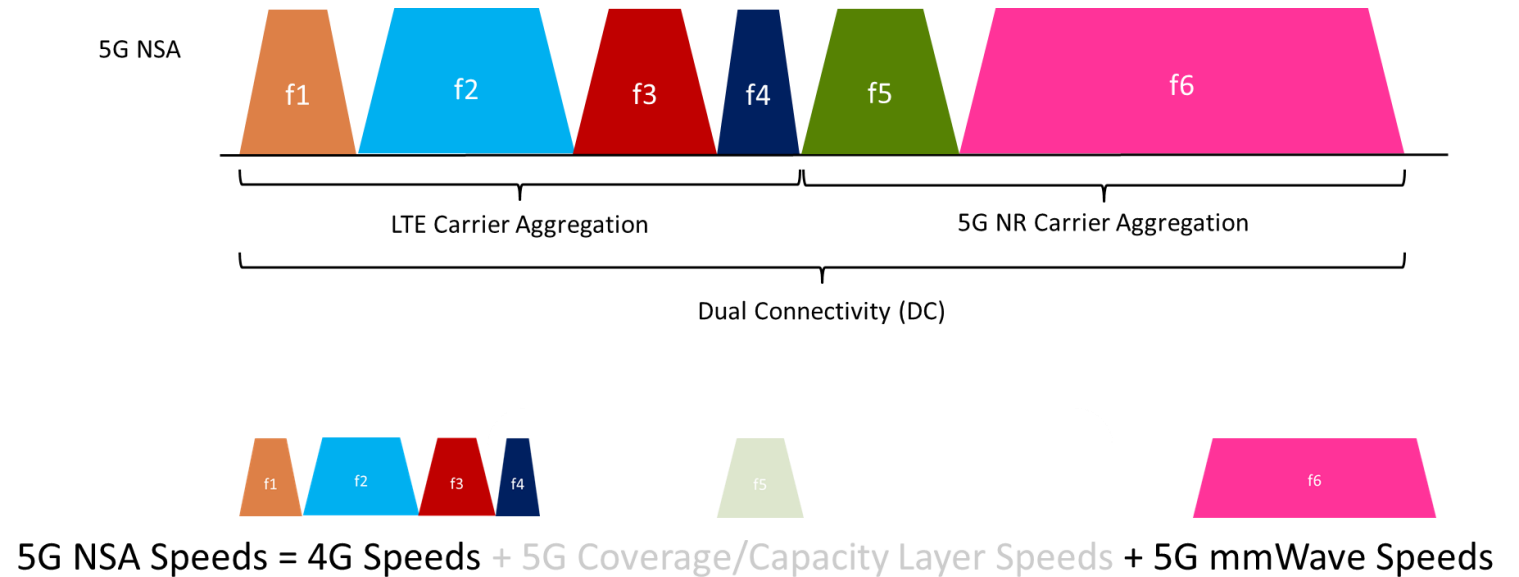
# 45: mmWave Penetration

---

- Question: Is there any issue with mmWave penetrating indoors?
- Answer: Yes, see questions 29 and 32. mmWave gets attenuated significantly when it hits any object hence indoor penetration could be an issue. On the other hand, mmWave is ideal for outdoor / indoor isolation as the mmWave also doesn't overflow outside from indoors.

# 46: mmWave Penetration – Part 2

- Question: Many demos show mmWave penetrating indoors from outside. How come?
- Answer: We get this question all the time. Nearly all of the 5G demos with mmWave are NSA 5G. Even if the mmWave spectrum gets completely attenuated, the 4G spectrum continues to function normally. The speeds you see are aggregated throughput speeds. Should the device show 5G icon in this case? Read details [here](#).



# 47: Private 5G Spectrum

---

- Question: What Spectrum can Private 5G use?
- Answer: Private 5G can use any of the 5G spectrum in use today. In addition some of the spectrum being released on shared basis can be used for 5G too. For example the CBRS spectrum in USA is the same as Capacity Layer 5G used everywhere else. So operators can deploy private 5G in this spectrum.

In the UK, Ofcom has made 3.8 GHz to 4.2 GHz on a lightly licensed basis. This will also be used for private 5G in future.

# 48: mmWave Indoors

---

- Question: Can mmWave be used for private networks indoors?
- Answer: Yes, there is no reason why it can't. mmWave provides excellent isolation between rooms and from outdoors to indoors and vice versa. The real challenge will be that ideally mmWave requires line of sight or near line of sight for best results. As long as the equipment indoors can cater for this, this can work well.

# 49: Cost of Spectrum

---

- Question: How much does different type of spectrum cost?
- Answer: The price of spectrum varies by country but the general observation is that the coverage layer spectrum is the most expensive, followed by capacity layer and the mmWave spectrum is the cheapest.

On Operator Watch Blog, you can see the prices of spectrum from [Italy](#), [Switzerland](#) and [Spain](#).

# 50: Low Prices for mmWave

---

- Question: Why is mmWave comparatively cheap?
- Answer: Mainly because mmWave cannot be deployed everywhere. mmWave works best with small or smaller cells hence their utilization is restricted to dense urban, urban or for FWA. This is the main reason the mmWave spectrum is comparatively cheaper than coverage or capacity layer spectrum.

# Thank You

To learn more, visit:

3G4G Website – <https://www.3g4g.co.uk/>

3G4G Blog – <https://blog.3g4g.co.uk/>

Operator Watch – <https://operatorwatch.3g4g.co.uk/>

Connectivity Technology Blog – <https://www.connectivity.technology/>

3G4G Small Cells Blog – <https://smallcells.3g4g.co.uk/>

Follow us on Twitter: <https://twitter.com/3g4gUK>

Follow us on Facebook: <https://www.facebook.com/3g4gUK/>

Follow us on LinkedIn: <https://www.linkedin.com/company/3g4g>

Follow us on SlideShare: <https://www.slideshare.net/3G4GLtd>

Follow us on YouTube: <https://www.youtube.com/3G4G5G>