通訊事務管理局辦公室
OFFICE OF THE COMMUNICATIONS AUTHORITY

"Science in the Public Service" Lecture Series

Understanding the Fifth Generation Mobile (5G) Services

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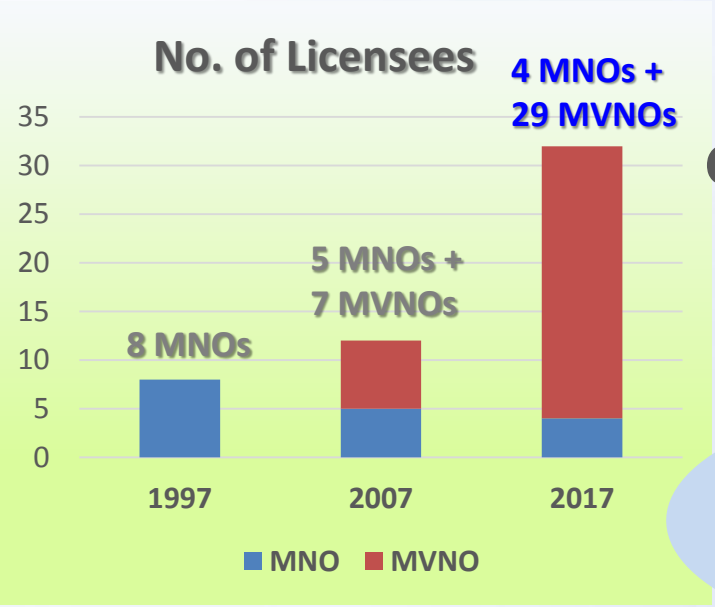
Office of the Communications Authority

22 October 2017

Mobile Market Landscape

Mobile Market



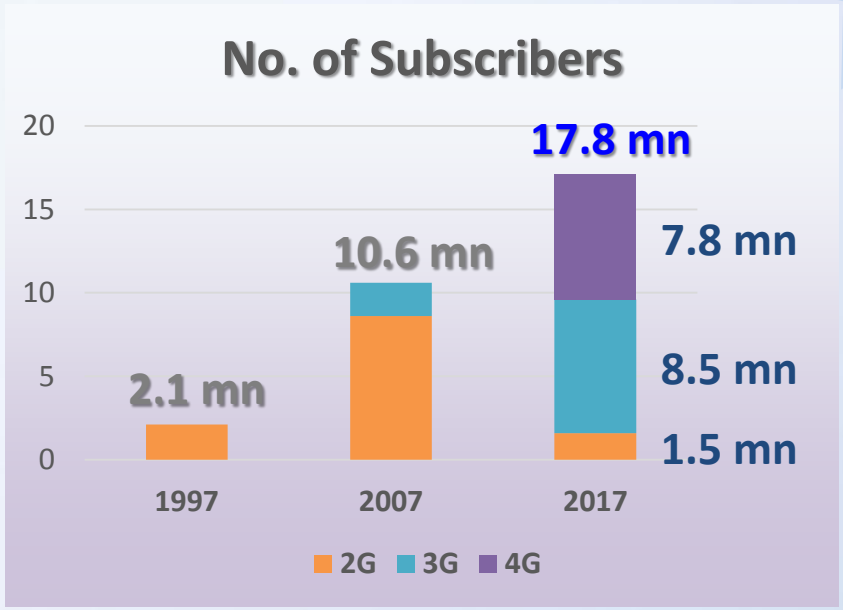
WORLD ECONOMIC FORUM

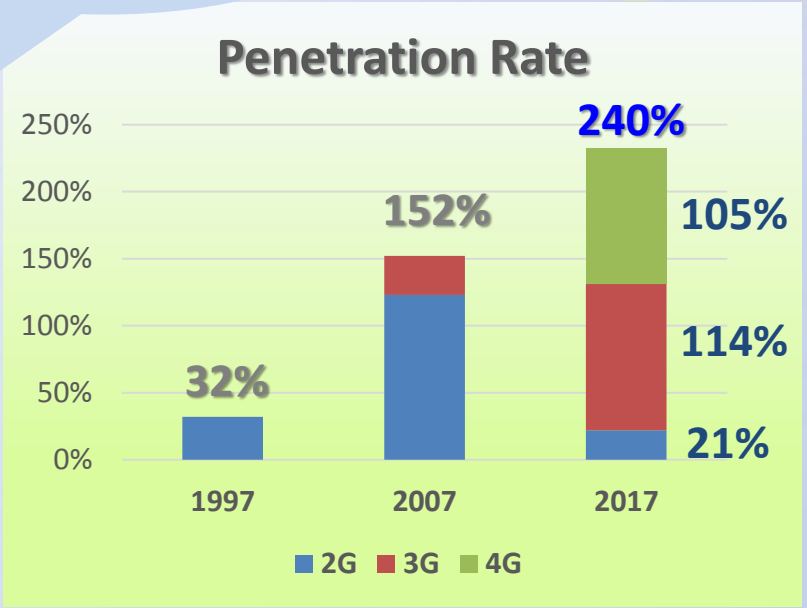
Global Ranking

MNO – Mobile Network Operator
MVNO – Mobile Virtual Network Operator

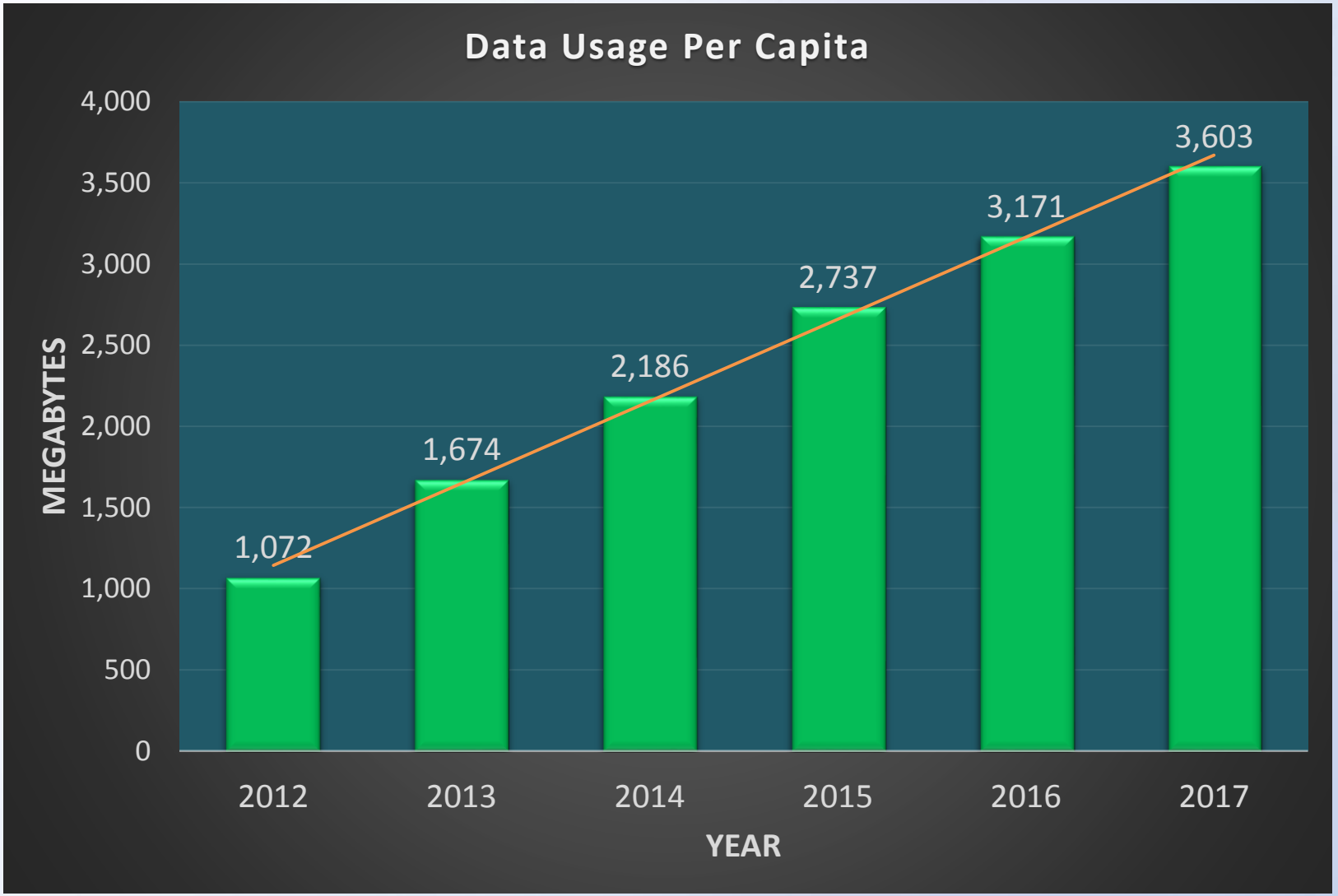
Mobile subscriber penetration

Mobile network coverage





Mobile Data Usage



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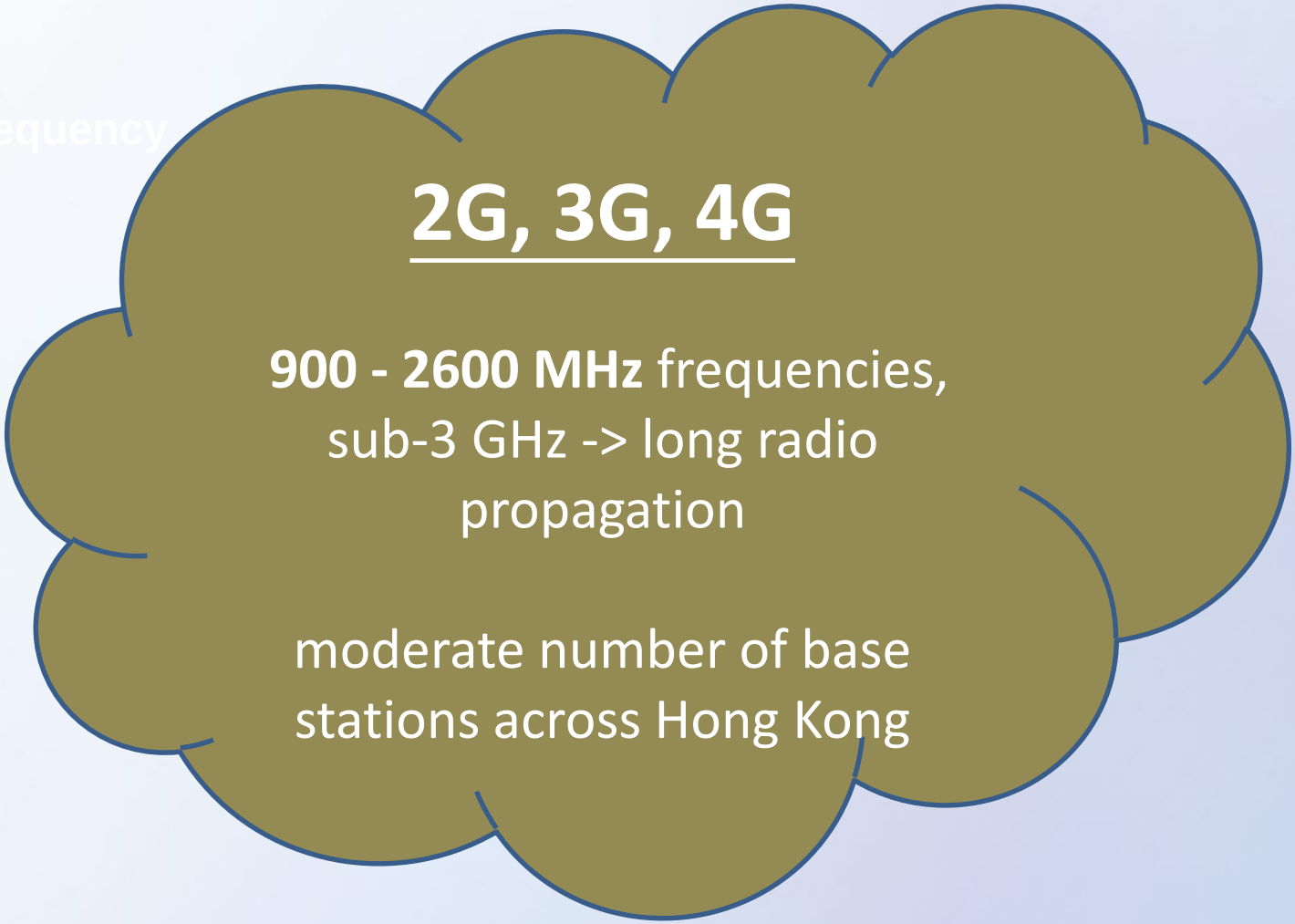
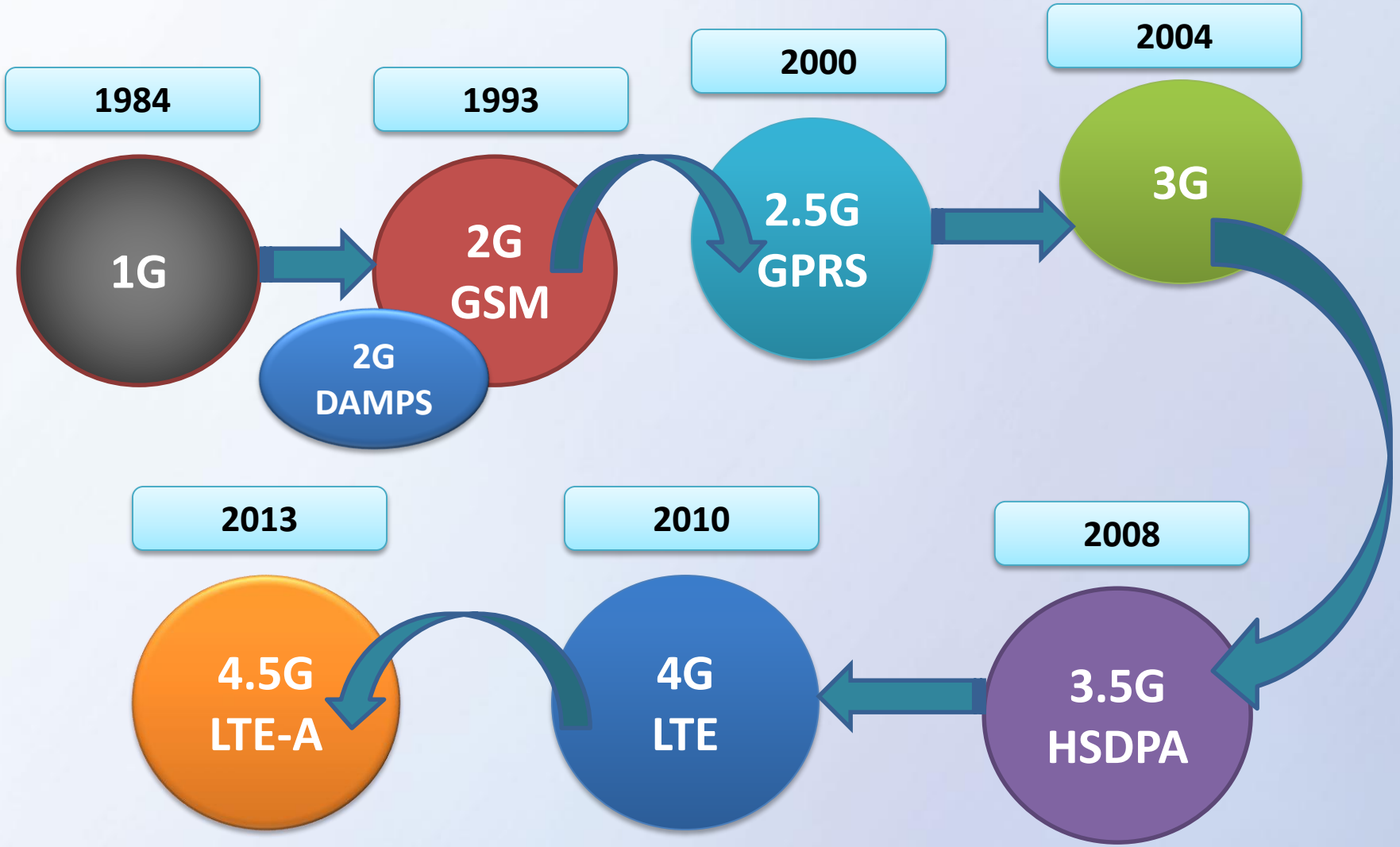
Frequencies and Coverage under 2G, 3G and 4G



Different Generations of Public Mobile Services

Different Generations of Public Mobile Services (1)



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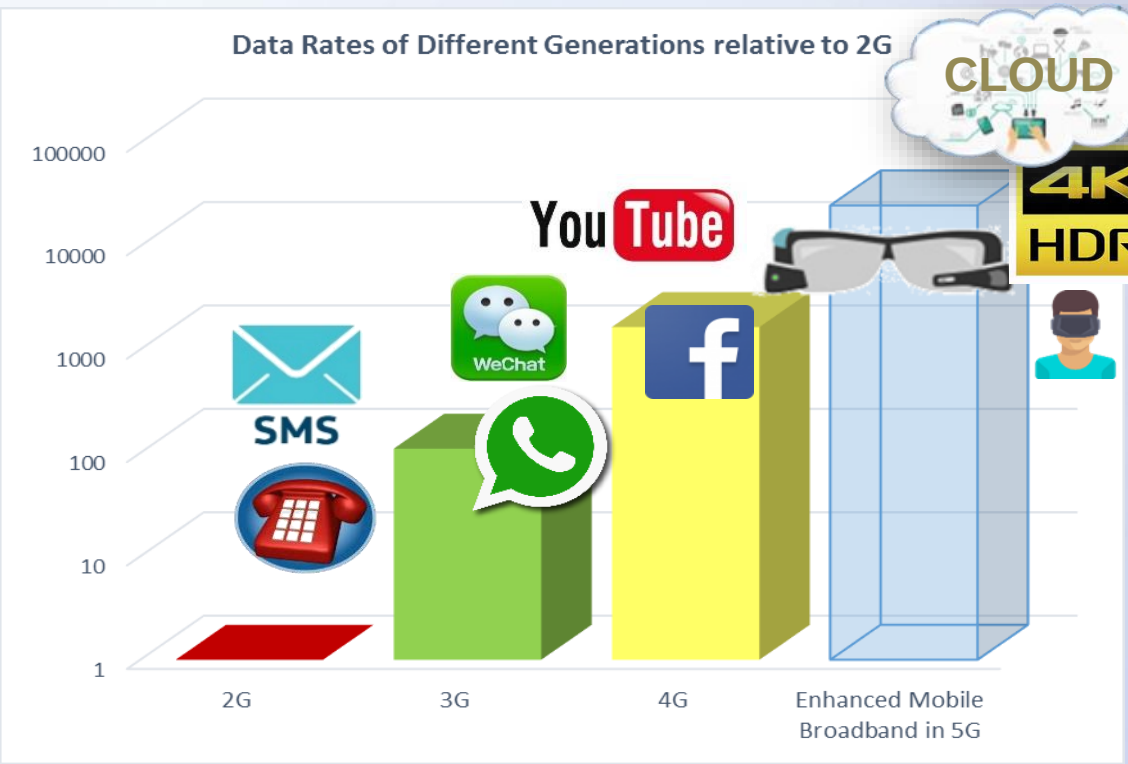
Different Generations of Public Mobile Services (2)

Ever-expanding demand for higher data speeds since 2G era

(2G speeds - 128 kbps to 384 kbps GPRS)

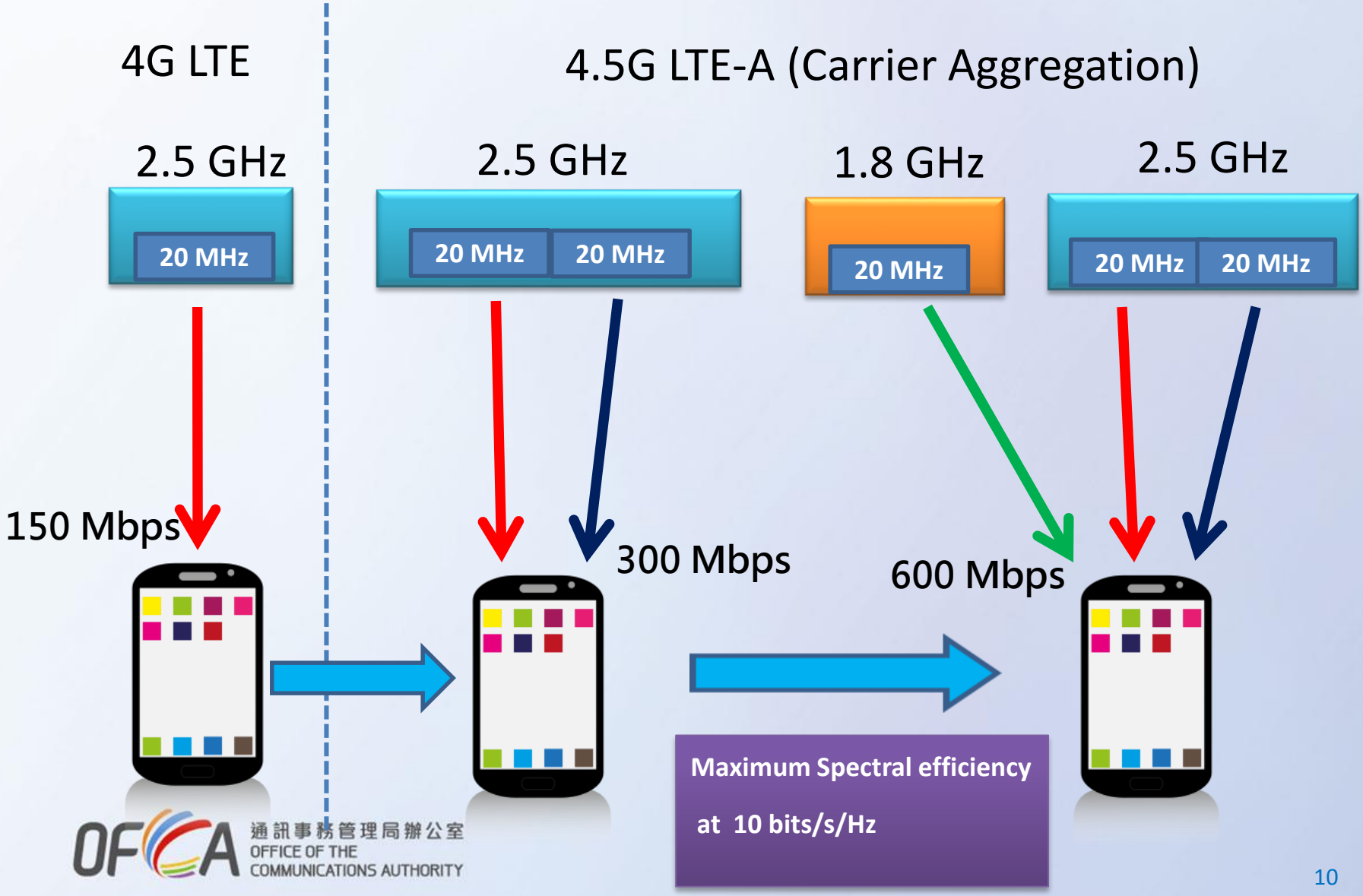


Virtual Reality, Augmented Reality

Different Generations of Public Mobile Services (3)

Generation	3G	4G	5G
Downloading a high-resolution movie (8GB) takes	26 hrs	6 mins	4 secs
Time equivalent to	Long-haul flight	Exercise	Sip a drink

Between 4G and 5G



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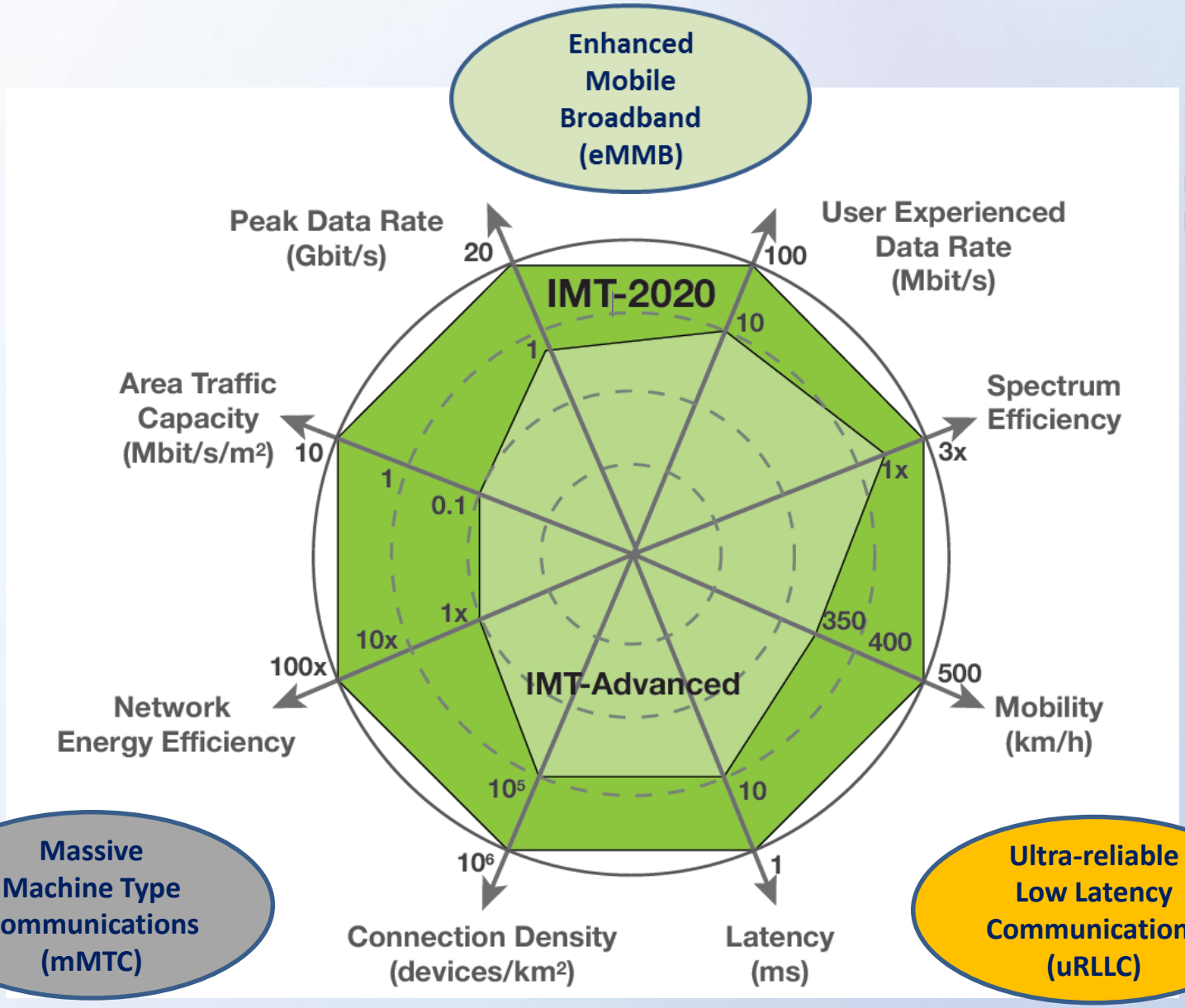
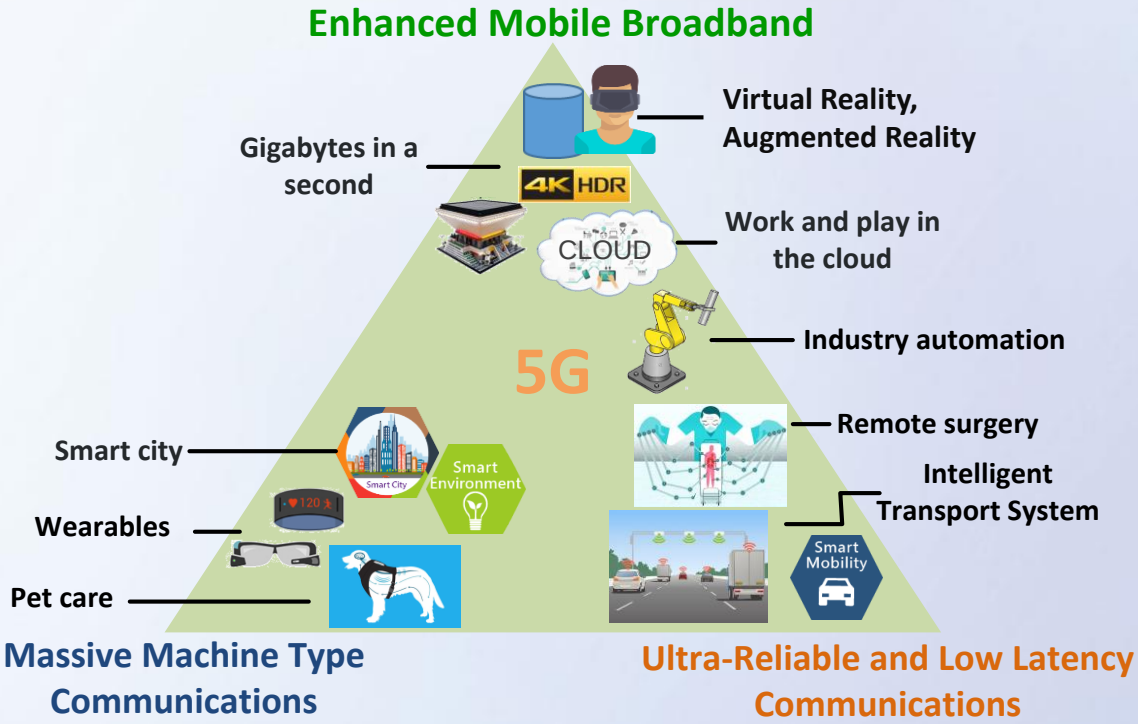
5G : Next Generation of Public Mobile Services

ITU 5G Key Performance Indicators



Reference:
Recommendation
ITU-R M.2083-0

Categories of Applications

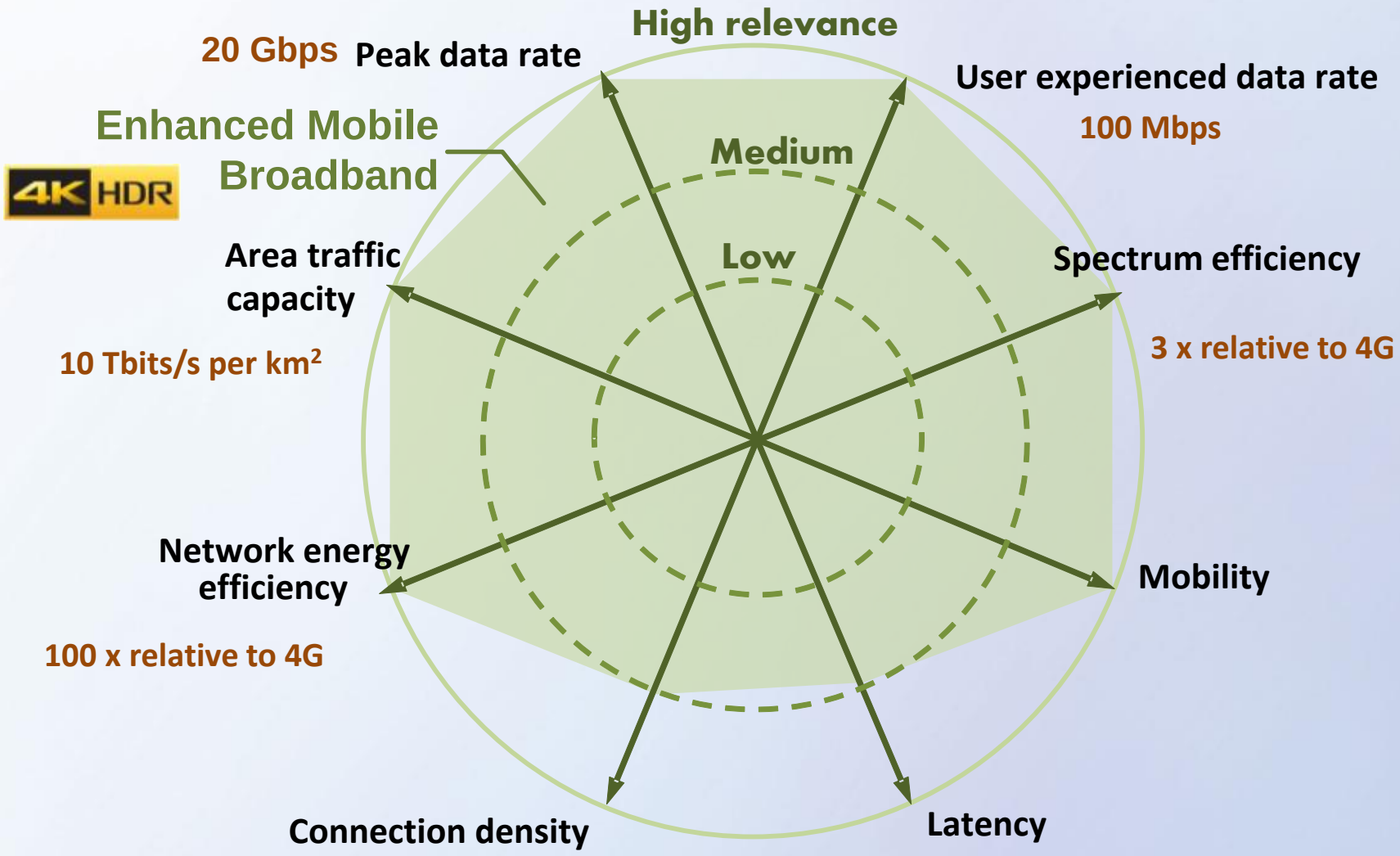


5G service provision

Poses unprecedented demand on spectrum

Supplements, but not to replace 2G, 3G or 4G

Capabilities of Enhanced Mobile Broadband



From Shannon to 5G

Shannon Capacity Equation published in 1948

$C = B \times \log_2 (1 + S/N)$

C= channel capacity in bits/s
B= bandwidth in Hertz
S/N= ratio of signal power to noise power

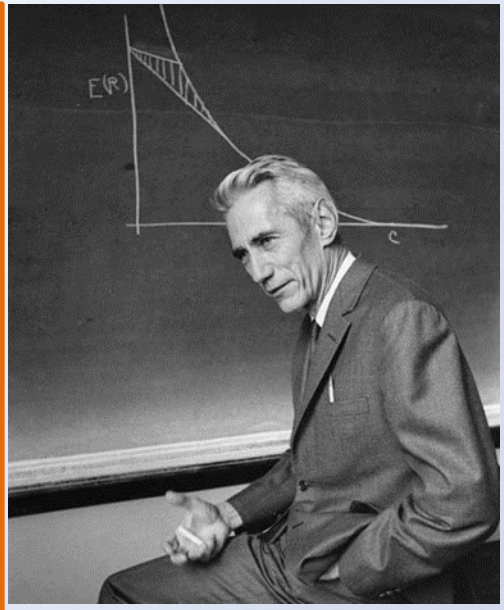
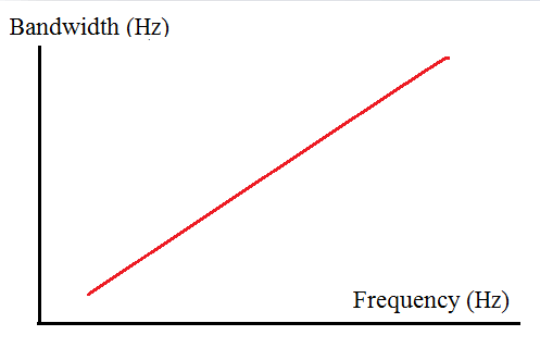


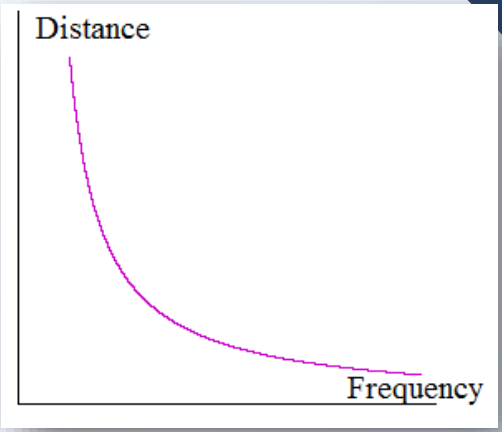
Photo courtesy - MIT Museum

Higher Frequency Bands for 5G



Higher frequency band provide higher bandwidth → higher data rate

Tradeoff – higher propagation loss at higher frequency



26GHz versus 2 GHz, attenuation increase by 170 times

Massive MIMO and Beamforming help resolve the situation

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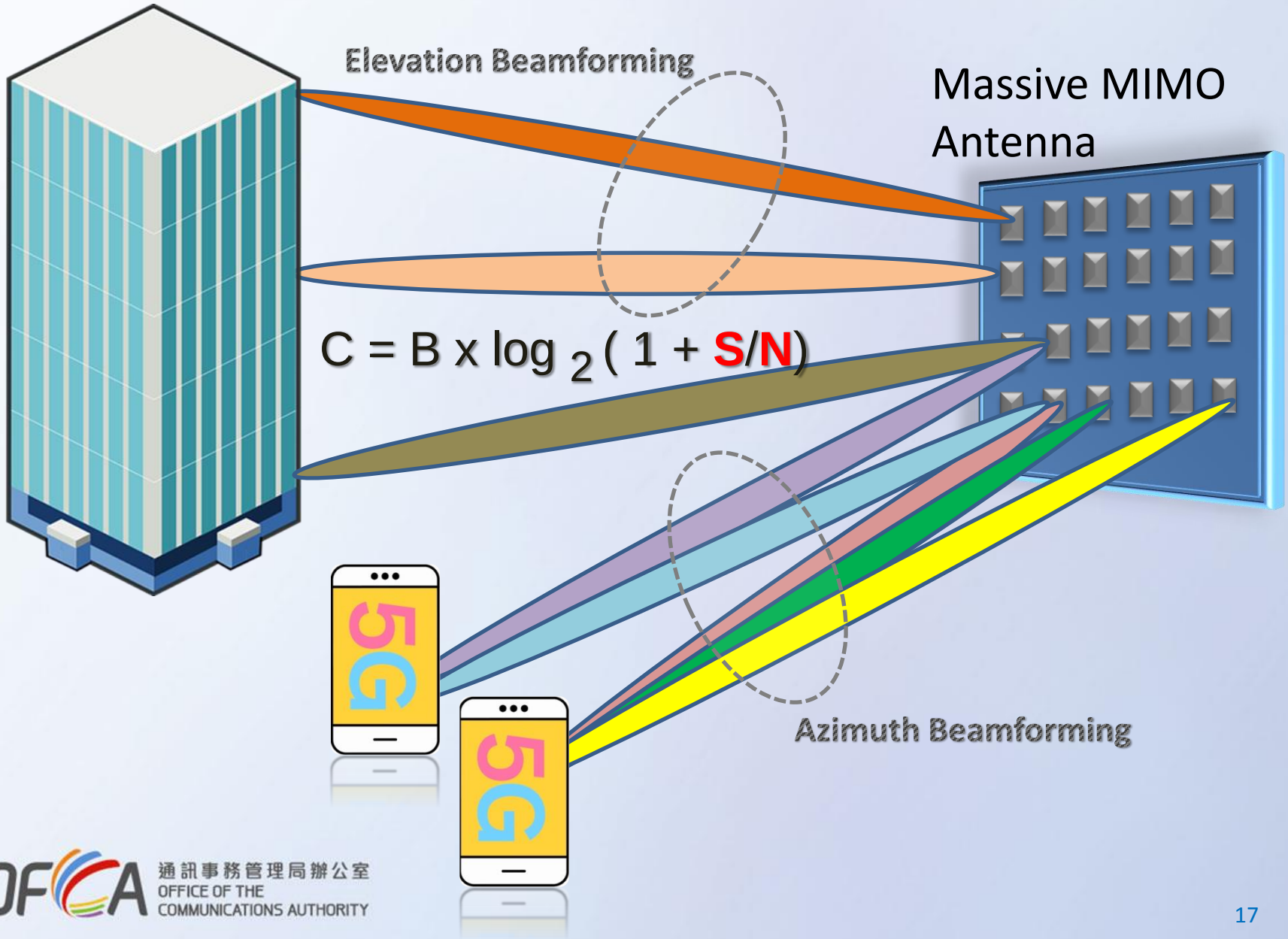
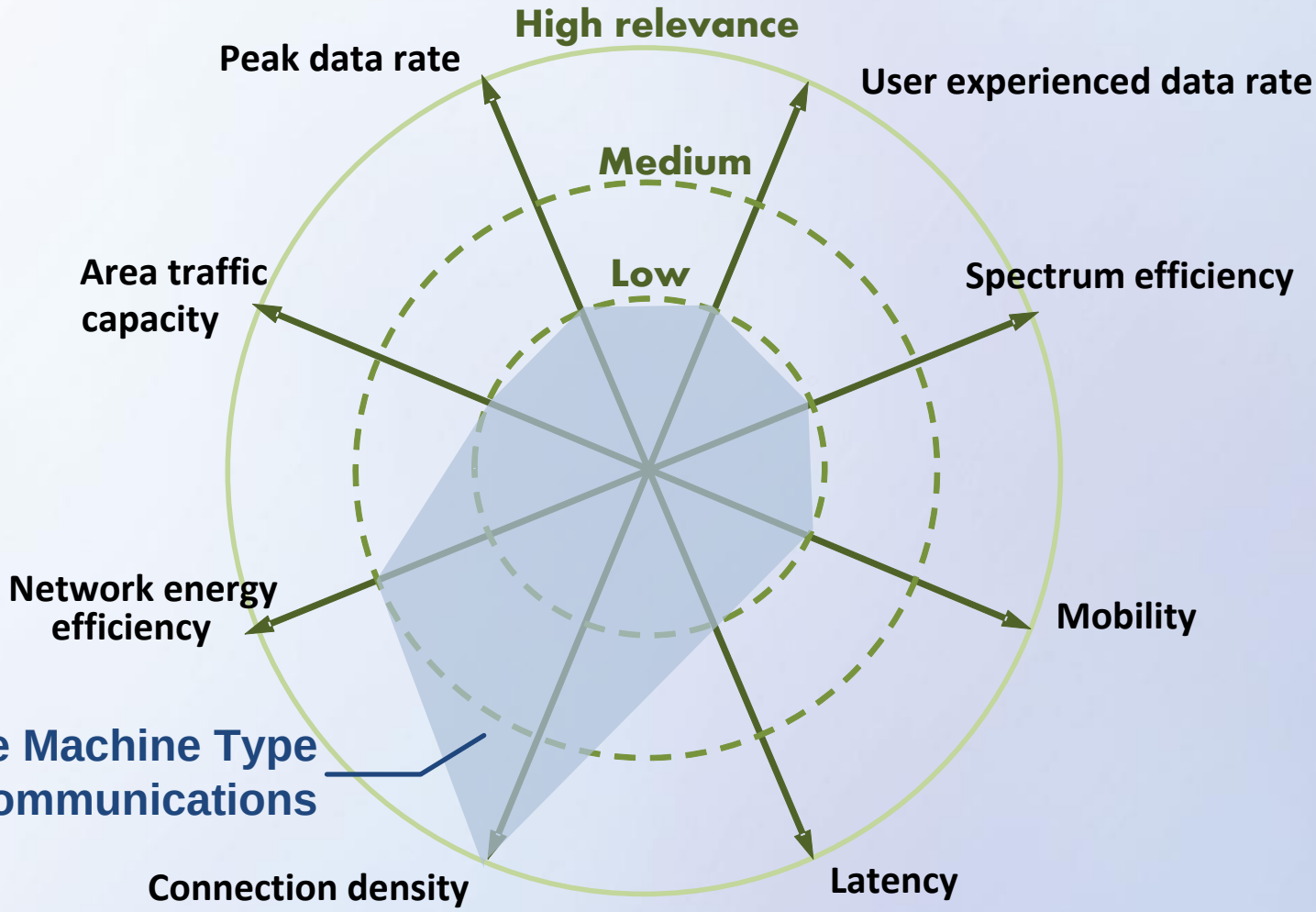
Massive MIMO and Beamforming



Capabilities of Massive Machine Type Communications



1 million devices per km^2

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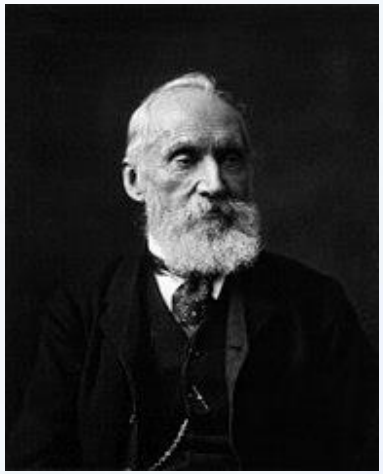
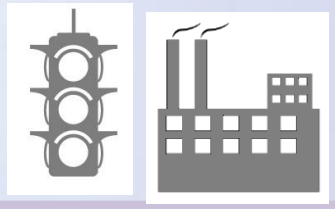
Use of Machine Type Communications



If you can not measure it, you can not improve it.

-Lord Kelvin, 1824 – 1907-



sense, monitor, detect

communicate

analyse, process, improve efficiency and safety

Courtesy: photo of Lord Kelvin from Wikimedia

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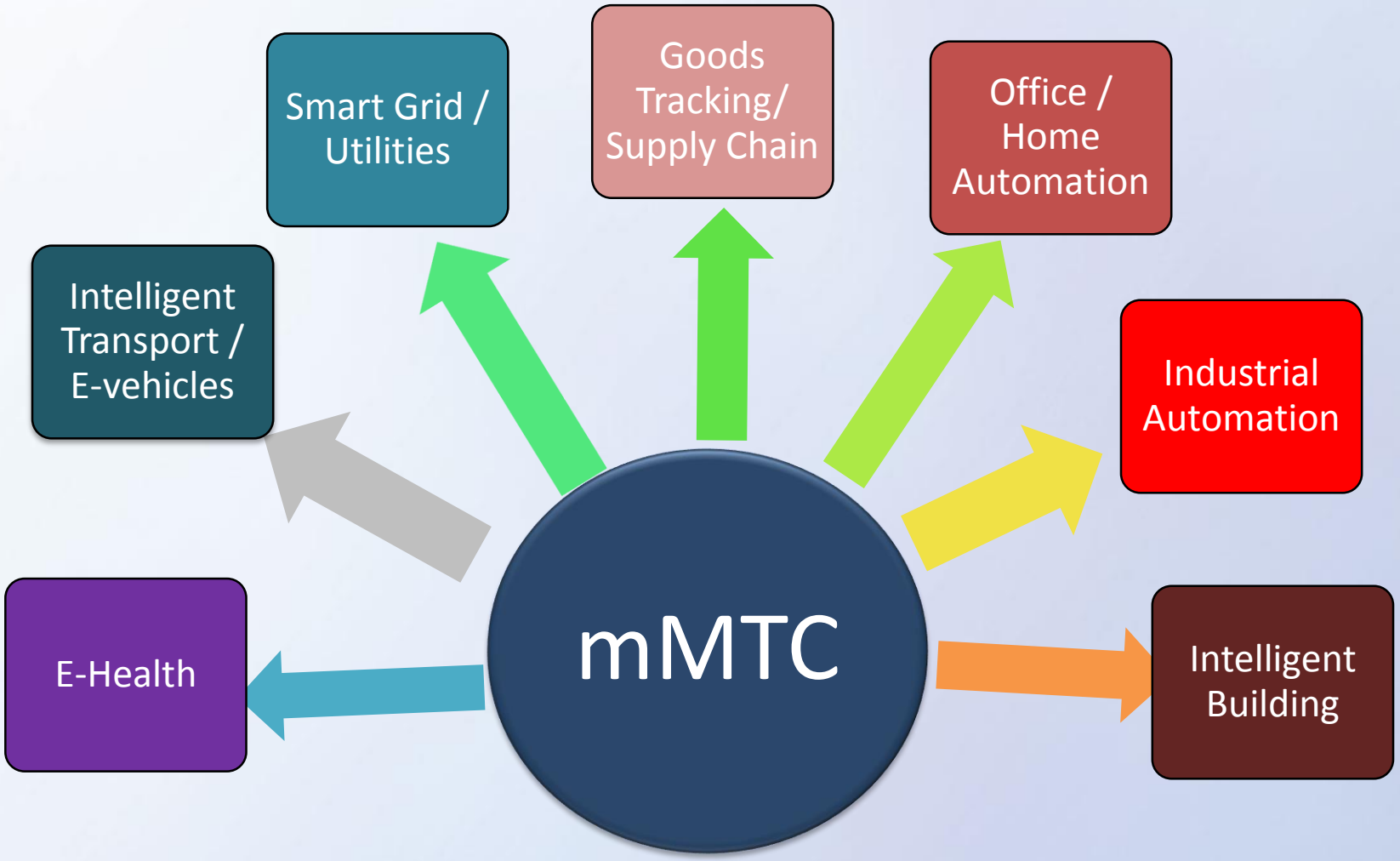
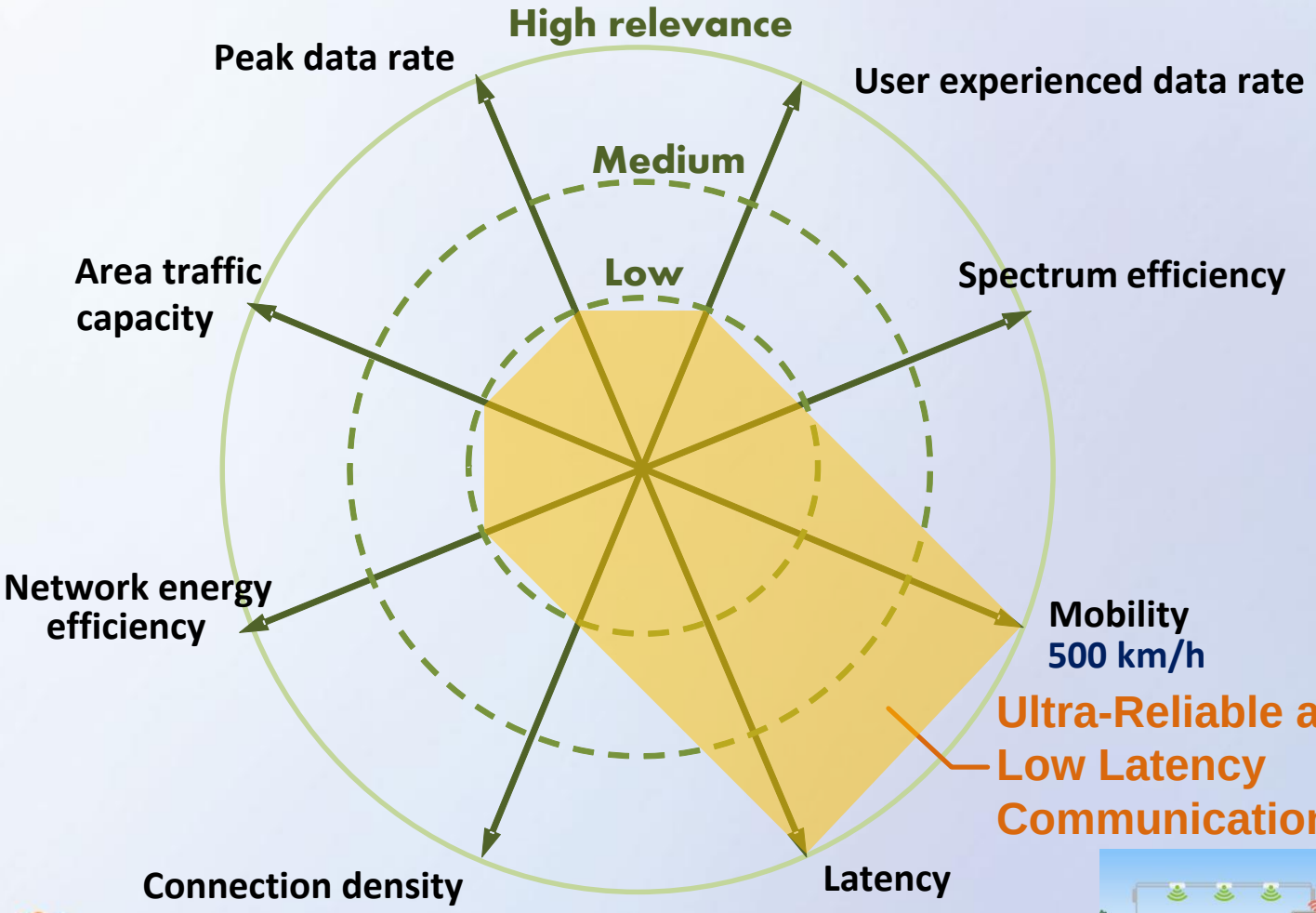
Massive Machine Type Communications (mMTC)



Capabilities of Ultra-Reliable and Low Latency Communications



Smart Mobility

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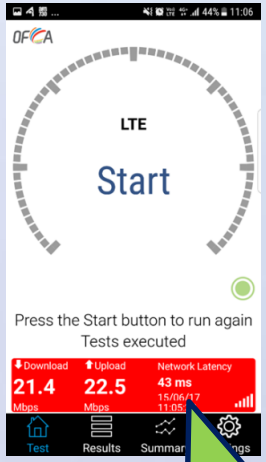
Conceptual Sketch - Low Latency in Auto-driving

Self-driving car
speed at 100 km/hr

4G LTE
Network

moved **60 cm** to stop
upon receiving command from
the network



43 ms
End-to-end
network latency

5G
Network

1 ms over the air,
5 ms end-to-end

Moved **7 cm** to stop
upon command from the network

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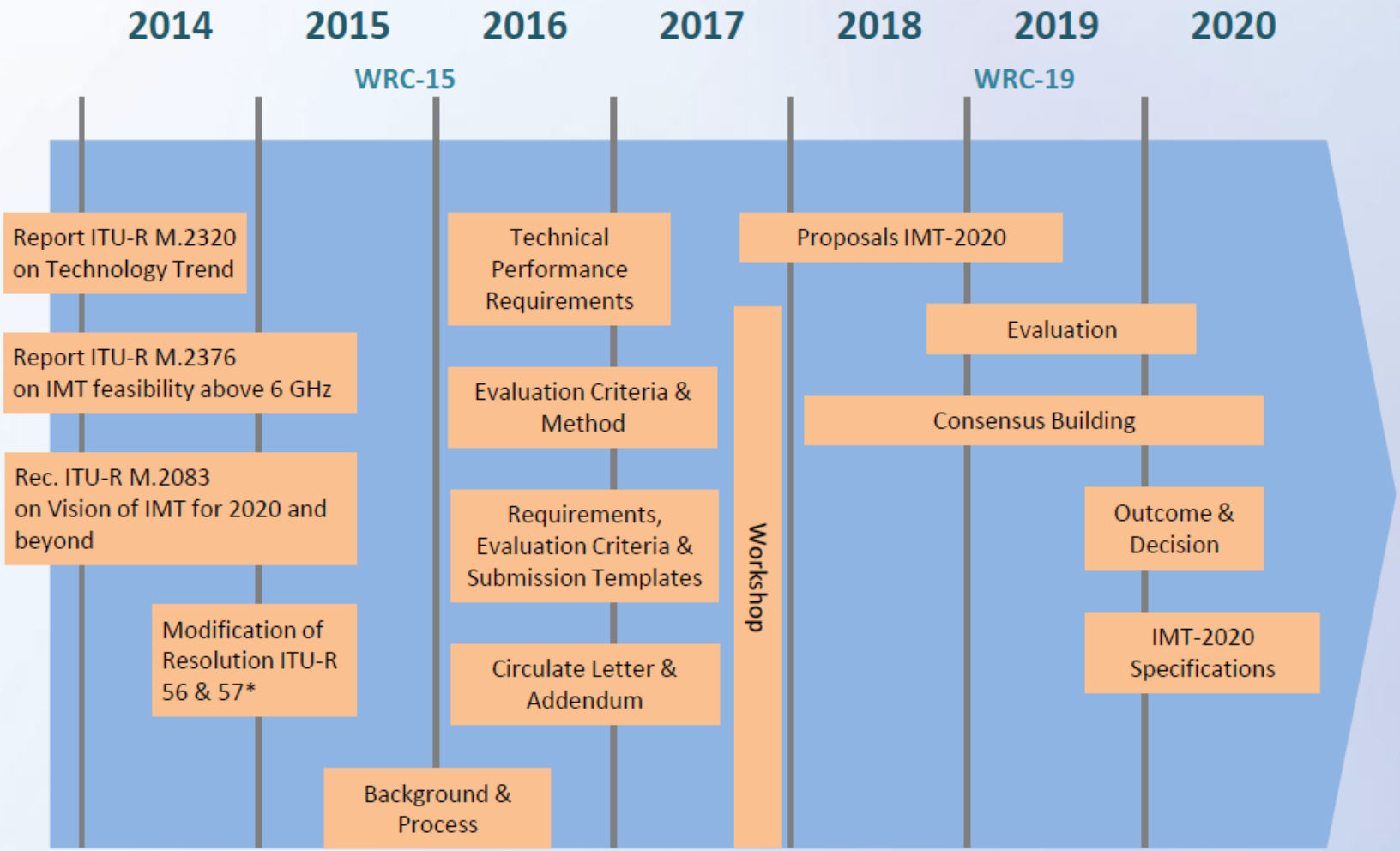
ITU 5G Specification Timelines



Reference: Working Party 5D Document - Workplan, timeline, process and deliverables for the future development of IMT

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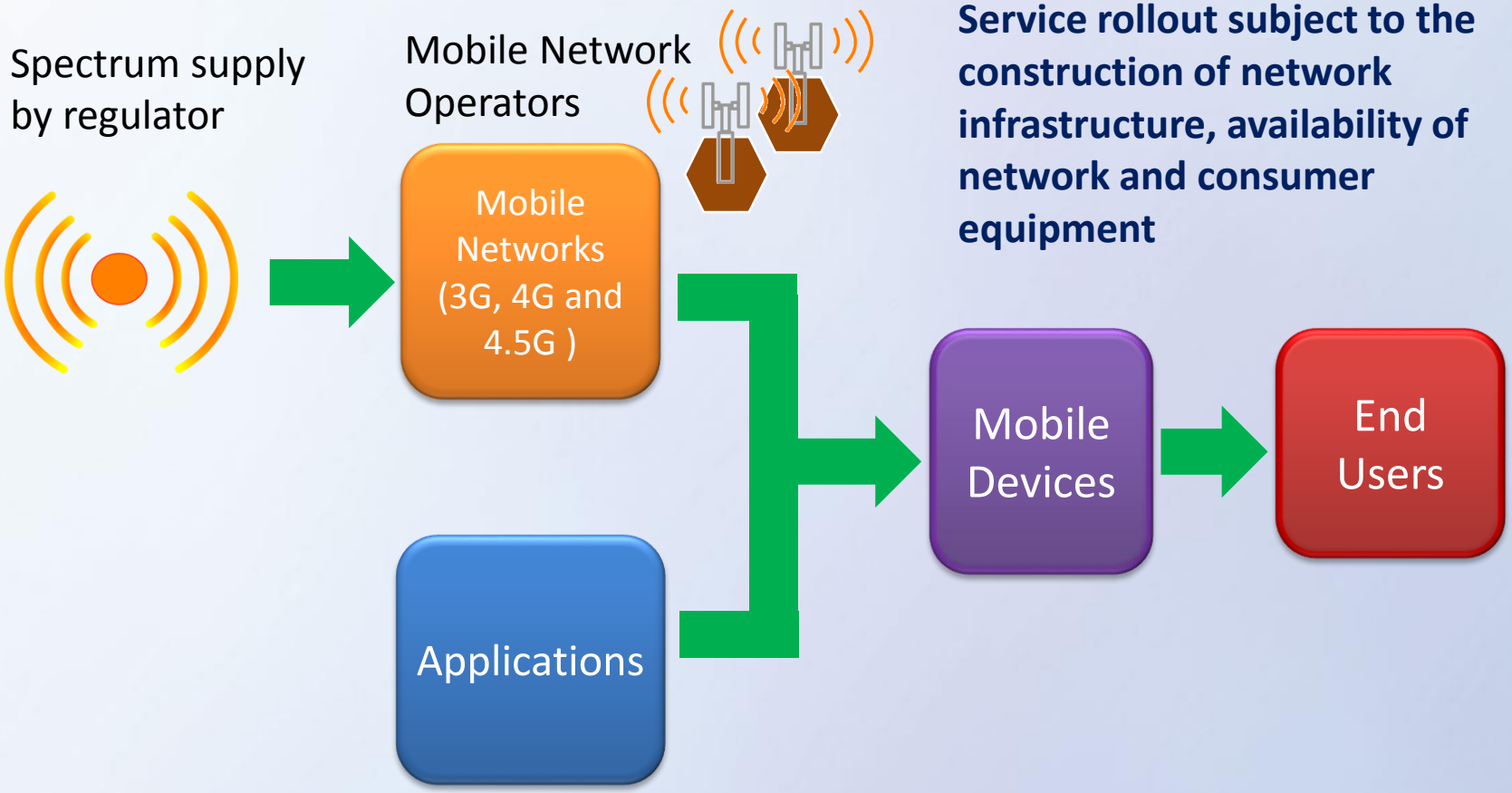
Spectrum for 5G

Mobile Ecosystem



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Next WRC in 2019

Global spectrum allocation by International Telecommunication Union (ITU)

World Radiocommunication Conference (WRC) held every 3 - 4 years

- Next WRC in 2019

Agenda Item 1.13 of WRC-19:
Identification of frequency bands (24.25 – 86 GHz) for future development of IMT

Current Spectrum and Possible 5G Spectrum

Existing public mobile spectrum in use (all below 3 GHz)

Frequency Bands	Available Bandwidth
850/900 MHz	84.8 MHz
1800 MHz	148.8 MHz
1900 – 2200 MHz	118.4 MHz
2300 MHz	60 MHz
2500/2600 MHz	140 MHz

Total Bandwidth: **552 MHz**

Vacant spectrum below 3 GHz

Frequency Bands	Available Bandwidth
1900/2200 MHz	34.6 MHz

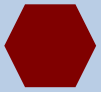
ITU candidate spectrum above 6 GHz

Frequency Bands	Available Bandwidth
24.25 – 27.5 GHz	3.25 GHz
31.8 – 33.4 GHz	1.6 GHz
37 – 40.5 GHz	6.5 GHz
40.5 – 42.5 GHz	
42.5 – 43.5 GHz	
45.5 – 47 GHz	4.7 GHz
47 – 47.2 GHz	
47.2 – 50.2 GHz	
50.4 – 52.6 GHz	2.2 GHz
66 – 76 GHz	10 GHz
81 – 86 GHz	5 GHz

Total Bandwidth:
33.25 GHz or (33,250 MHz)

Possible New Spectrum Below 6 GHz

- Favourable propagation characteristics of spectrum at low frequencies (sub-6 GHz)
- Suitable for territory-wide coverage

	Mobile cell site of sub-6GHz spectrum Large in size -> large coverage
	Mobile cell site of 24.25 – 86 GHz spectrum Small in size -> small coverage

Using sub-6GHz spectrum

Using spectrum of 24.25 – 86 GHz

Coverage of cell sites of 24.25 – 86 GHz spectrum is small. These cell sites would typically be used in clusters

- Candidate band: 3.5 GHz (3.4 – 3.6 GHz)

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5G Development Elsewhere

5G Promotion Groups established in Other Economies

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Development and Milestones in Other Economies

Japan

- Field trials since 2015
- 5G services to be launched before **2020 Tokyo Olympic Games**

Korea

- Launch of the 5G national strategy
- 5G services to be offered in **Pyeongchang Winter Olympic Games in 2018**

Mainland China

- Technology trial over 2016 -2018
- Product trial over 2018 – 2020
- China Mobile plan to **rollout commercial service in 2020**

5G activities around the world

United States

- Spectrum in high **frequency bands opened up in 2016 for 5G service development**
- 5G experiments using mixed frequency bands since 2016

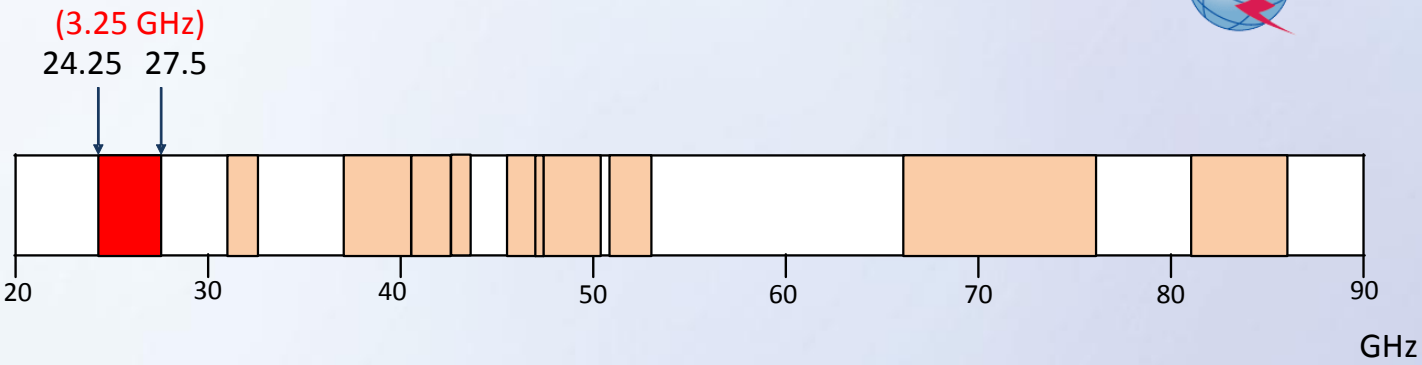
European Union

- An action plan published in 2016, towards **initial deployment of 5G networks by 2018 and commercialisation by end 2020**
- Projects of 5G PPP and METIS (Mobile and wireless communications Enablers for 2020 Information Society)

CA's Work Plan for Making Available Spectrum for 5G

CA's Work Plan for Making Available Spectrum for 5G (1)

- New spectrum identification: 26 GHz Band (24.25 – 27.5 GHz)
  - An ITU candidate band (lowest in frequency)



Used by fixed services in HK, 11% utilisation as microwave links

Being considered for 5G

Spectrum vacation and relocation of existing link assignments before April 2019

CA's Work Plan for Making Available Spectrum for 5G (2)

- 28 GHz Band (27.5 – 28.35 GHz)

Currently not in use

Spectrum opened up in the US; Trials in the US and Korea; Implementation as early as 2018

PyeongChang 2018

- The 26 GHz & 28 GHz Bands

Large bandwidth of 4.1 GHz

Invitation for Expression of Interest in Q4 2017 to gauge industry interest

CA's Work Plan for Making Available Spectrum for 5G (3)

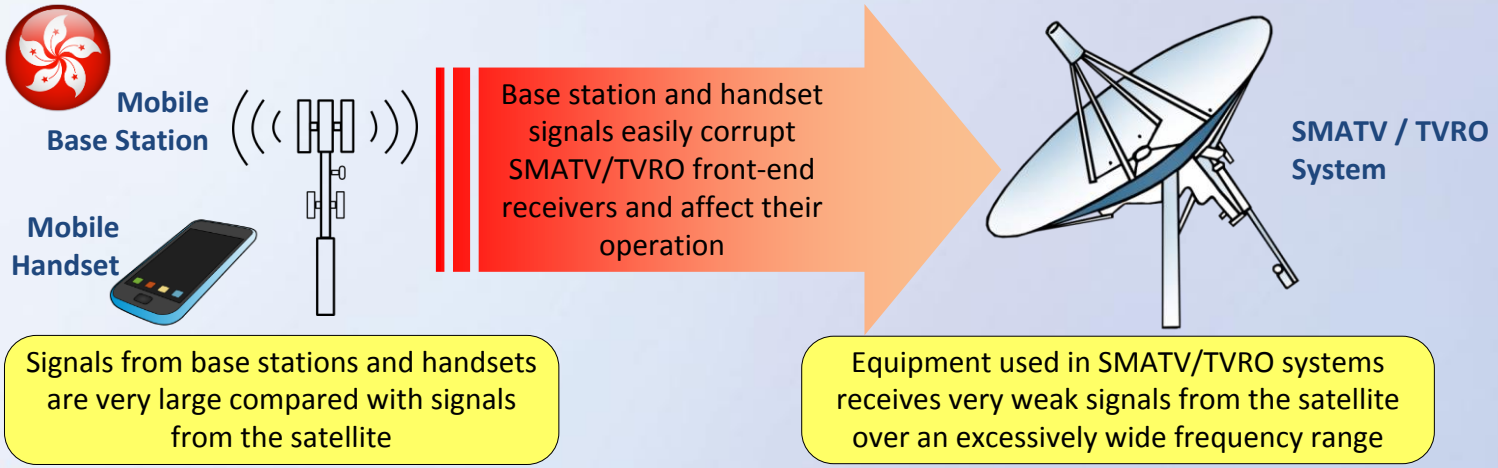
- 3.5 GHz Band (3.4 – 3.6 GHz)

3.4 – 4.2 GHz band allocated for fixed satellite service, with around 1,600 SMATV system with 890,000 user outlets in HK

IMT identification of the 3.5 GHz band

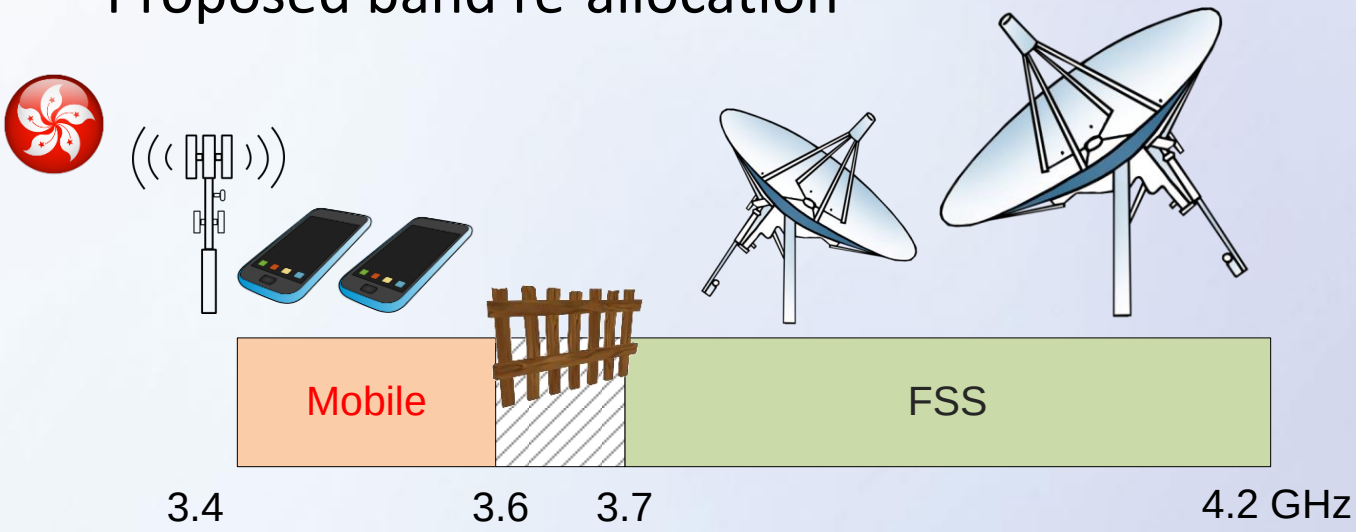
5G implementation being considered by many economies

But …



CA's Work Plan for Making Available Spectrum for 5G (4)

- 3.5 GHz Band (3.4 – 3.6 GHz)
  - Proposed band re-allocation



Technical consultancy study underway

Public consultation in July 2017, closed in Sept 2017, considering the submissions received

5G services will be commercially available in the time frame of 2020

Everyone is working towards that ...
and the CA is playing its crucial part to make it happen timely in Hong Kong

Thank you