

Radio Spectrum and Technical Standards Advisory Committee

SSAC Paper 8/2016 for Information: Update on Development of International Mobile Telecommunications ("IMT") for 2020 and Beyond

Office of the Communications Authority
2 June 2016

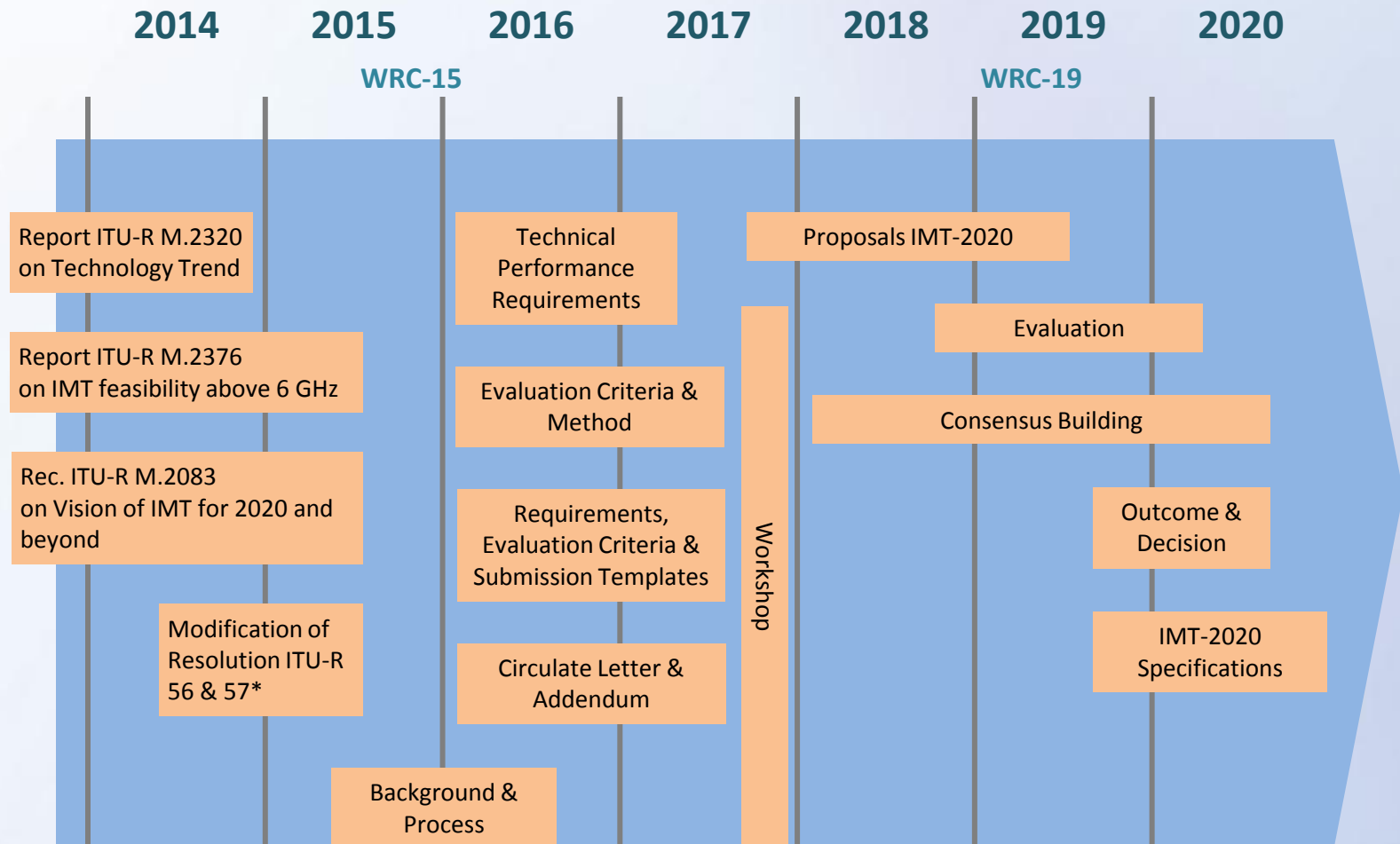
Background

- In early 2012, the International Telecommunication Union (“ITU”) embarked on a program to develop **IMT for 2020 and beyond (“IMT-2020”)**, setting the stage for **5G** research activities that are emerging around the world
- In collaboration with ITU, there are regional and national efforts devoted to the research and development of 5G technologies
- This paper shares for Members’ information on:
 - ITU’s work plan, timeline and process for IMT-2020 and related work of the Third Generation Partnership Project (“3GPP”)
 - Objectives and technology trend for IMT-2020 envisaged by ITU and some regional and national research and development efforts
 - Candidate frequency bands for IMT-2020

ITU Development of IMT-2020

- **Working Party 5D (“WP 5D”)** of ITU-R Study Group 5 takes the leading role in the development of IMT-2020 within ITU
- At the meeting of October 2014, WP 5D agreed on the detailed timeline and process for IMT-2020 in ITU

ITU Timeline and Process for IMT-2020



* Resolution ITU-R 56 : Naming for International Mobile Telecommunications
 Resolution ITU-R 57 : Principles for the process development of IMT-Advanced

Work Accomplished within ITU

- Publication of the following key deliverables in relation to the 5G key elements –

Deliverable	Issue Date
New Report ITU-R M.2320-0 “Future technology trends of terrestrial IMT systems”	November 2014
New Report ITU-R M.2376-0 “Technical feasibility of IMT in bands above 6 GHz”	July 2015
New Recommendation ITU-R M.2083-0 “IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond”	September 2015

- Modification of **Resolution ITU-R 56 “Naming for IMT”** –
 - ✎ Essentially, the term **“IMT-2020”** is used to refer to those systems, system components and related aspects that include new radio interface(s) that support new capabilities of systems **beyond IMT-2000 and IMT-Advanced (for 2020 and beyond)**, the framework and overall objectives for future development of which are described in **Rec. ITU-R M.2083**

WRC-19 Agenda Item relating to IMT (1)

- WRC-15 passed **Resolution 809** resolving to recommend to hold a world radiocommunication conference in 2019 (i.e. WRC-19) and the proposed agenda items. [WRC-19 agenda item 1.13](#) is about IMT

WRC-19 Agenda Item 1.13

To consider identification of frequency bands for the future development of International Mobile Telecommunications (IMT), including possible additional allocations to the mobile service on a primary basis, in accordance with **Resolution 238 (WRC-15)**

Resolution 238 (WRC-15)

Studies on frequency-related matters for IMT identification including possible additional allocations to the mobile services on a primary basis in portions of the frequency range between 24.25 GHz and 86 GHz for future development of IMT for 2020 and beyond

WRC-19 Agenda Item relating to IMT (2)

- **Resolution 238 (WRC-15)**

- *Resolves to invite ITU-R* **①**

to conduct and complete in time for WRC-19 appropriate studies to determine the spectrum needs for IMT terrestrial component in the frequency range 24.25 – 86 GHz, taking into account –

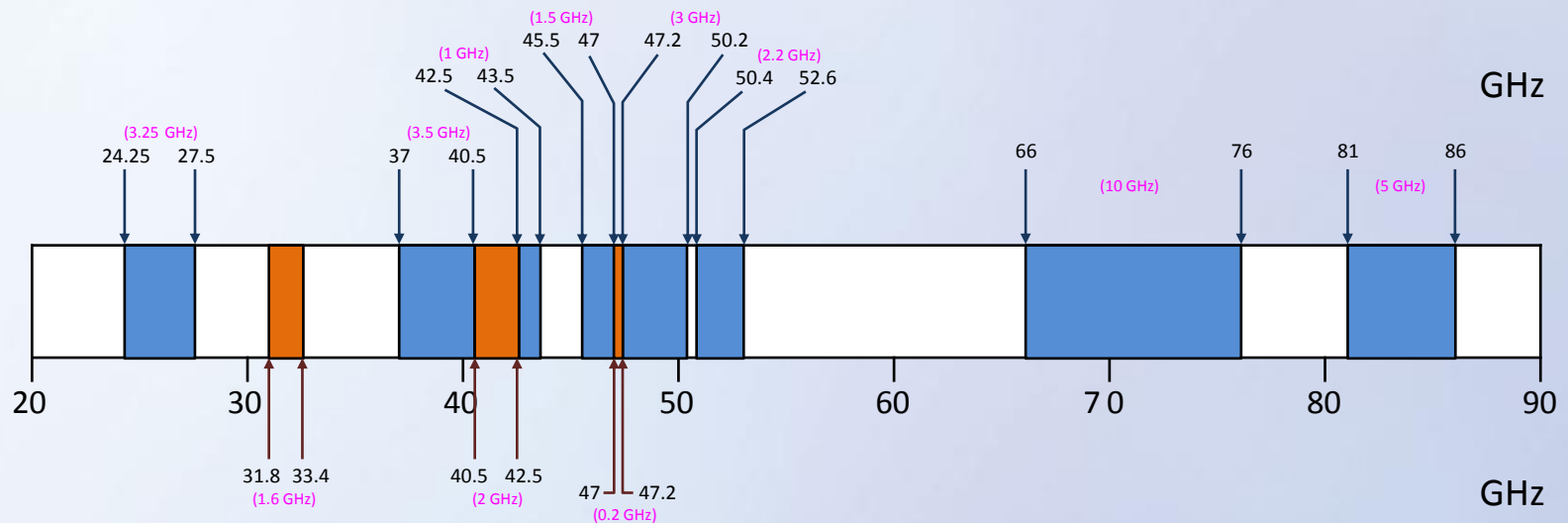
- technical and operational characteristics of terrestrial IMT systems
- deployment scenarios envisaged for IMT-2020 systems
- needs of developing countries
- timeframe in which spectrum would be needed

WRC-19 Agenda Item relating to IMT (3)

- Resolution 238 (WRC-15)

- Resolves to invite ITU-R (2)

to conduct and complete in time for WRC-19 sharing and compatibility studies for the following frequency bands, taking into account protection of services to which these bands are allocated on a primary basis –



Frequency bands which have allocations to the mobile service on a primary basis

Frequency bands which may require additional allocations to the mobile service on a primary basis

WRC-19 Agenda Item relating to IMT (4)

- **Resolution 238 (WRC-15)**

➤ *Frequency bands identified in Resolves to invite ITU-R* **(2)**

Frequency bands which have allocations to the mobile service on a primary basis	Frequency bands which may require additional allocations to the mobile service on a primary basis
24.25 – 24.75 GHz	31.8 – 33.4 GHz
37 – 40.5 GHz	40.5 – 42.5 GHz
42.5 – 43.5 GHz	47 – 47.2 GHz
45.5 – 47 GHz	
47.2 – 50.2 GHz	
50.4 – 52.6 GHz	
66 – 76 GHz	
81 – 86 GHz	

WRC-19 Agenda Item relating to IMT (4)

- **Resolution 238 (WRC-15)**

- *Further resolves* ①

to invite CPM19-1* to define the date by which technical and operational characteristics needed for sharing and compatibility studies to be available

↗ CPM19-1 was convened in Geneva from 30 November to 1 December 2015. It organised the preparatory studies for WRC-19 and proposed a structure for its Report to WRC-19.

*CPM19-1 – First session of the Conference Preparatory Meeting for WRC-19

WRC-19 Agenda Item relating to IMT (5)

➤ Decisions of CPM19-1

Establish **Task Group TG 5/1** under ITU-R Study Group 5

All involved parties in frequency bands and services in **TG 5/1** are invited to actively participate in work on WRC-19 agenda item 1.13

In response to **Resolution 238** resolves to invite ITU-R **①**

ITU-R Working Party 5D to conduct and study the spectrum needs, technical and operational characteristics including protection criteria, and deployment scenarios for IMT terrestrial component **by 31 March 2017** and report the study results to TG 5/1

In response to **Resolution 238** resolves to invite ITU-R **②**

The technical characteristics including protection criteria for existing services allocated in, or adjacent to, the bands identified in **Resolution 238** resolves to invite ITU-R **②** to be provided by the involved Working Parties to TG 5/1 **by 31 March 2017**

Working Parties of ITU-R Study Group 3 to provide the relevant propagation models for sharing studies for the frequency bands listed in **Resolution 238** resolves to invite ITU-R **②** to TG 5/1 **by 31 March 2017**

TG 5/1 to conduct sharing and compatibility studies based on inputs from the ITU-R Working Parties

WRC-19 Agenda Item relating to IMT (6)

- **Resolution 238 (WRC-15)**

- *Further resolves* ②

to invite WRC-19 to consider, based on the results of the sharing and compatibility studies, any of the bands listed in *resolve to invite ITU-R* ② to be additionally allocated to the mobile service on a primary basis and to be identified for the terrestrial component of IMT

Vision for IMT-2020 of ITU as specified in Rec. ITU-R 2083-0

ITU's Vision for IMT-2020 (1)

- **User and Application Trends**

- Supporting high data rate, low latency and high reliability human-centric and machine-centric communications
- Supporting high user density and Internet of Things (IoT)
- Maintaining high quality at high mobility
- Enhanced multimedia services in areas like entertainment, medical treatment, safety and security

- **Drivers Influencing Growth in IMT Traffic**

- Adoption of devices with enhanced capabilities that require increased bit rates and bandwidth usage
- Increased video usage, device proliferation (e.g. IoT), application uptake

ITU's Vision for IMT-2020 (2)

- **Technology Trends**

- Technologies to enhance radio interface
 - Advanced modulation and coding scheme
 - Advanced multiple access scheme
 - Advanced antenna technologies including 3D beam forming, high order MIMO (Multiple Input Multiple Output)
 - TDD-FDD joint operation, dual connectivity and dynamic TDD
- Network technologies
 - Software-defined networking and network function virtualisation for optimal processing of node functions and improving operational efficiency
- Technologies to enhance massive machine type communications
 - Extensive device-to-device communication, and evolution to IoT
- Technologies to enhance privacy and security

ITU's Vision for IMT-2020 (3)

- **Technology Trends**

- Technologies to improve network energy efficiency
 - Adapt resource management to user traffic variation
 - For example, base station and antenna muting, traffic balancing among multiple radio access technologies
- Terminal technologies
 - Improved chip, battery and display technologies
- Technologies enabling higher data rates
 - Use higher frequency bands with large bandwidth available, e.g. between **6 and 100 GHz**; Carrier Aggregation
 - Enhanced spectral efficiency by means of, e.g. advanced modulation and coding, high order MIMO
 - Network densification, e.g. small cells

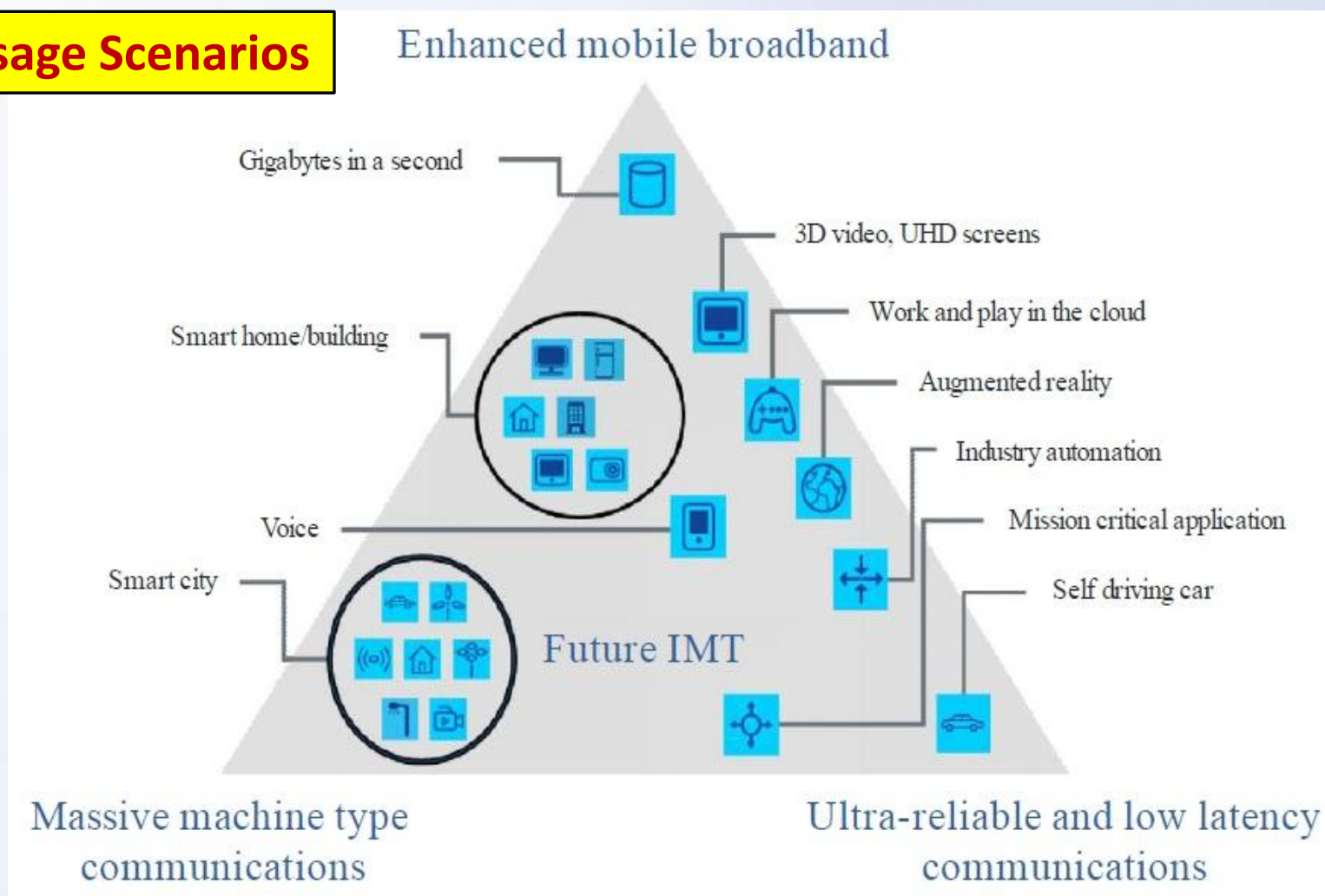
ITU's Vision for IMT-2020 (4)

- **Spectrum Issues**

- Contiguous and larger channel bandwidth required
 - Technical feasibility of IMT in frequencies between **6 and 100 GHz**
 - High frequency bands facilitate the use of the same spectrum for both access and backhaul, and the implementation of beam forming and MIMO
 - Large channel bandwidth allows the provision of gigabit per second user data rates required as a result of the proliferation of smart devices and a wide range of applications
- Spectrum harmonisation required
 - To harmonise existing and newly allocated and identified spectrum
 - To achieve commonality of equipment which facilitates economy of scale
 - To enable global roaming, reduce equipment design complexity, preserving battery life, and potentially reduce cross-border interference

ITU's Vision for IMT-2020 (5)

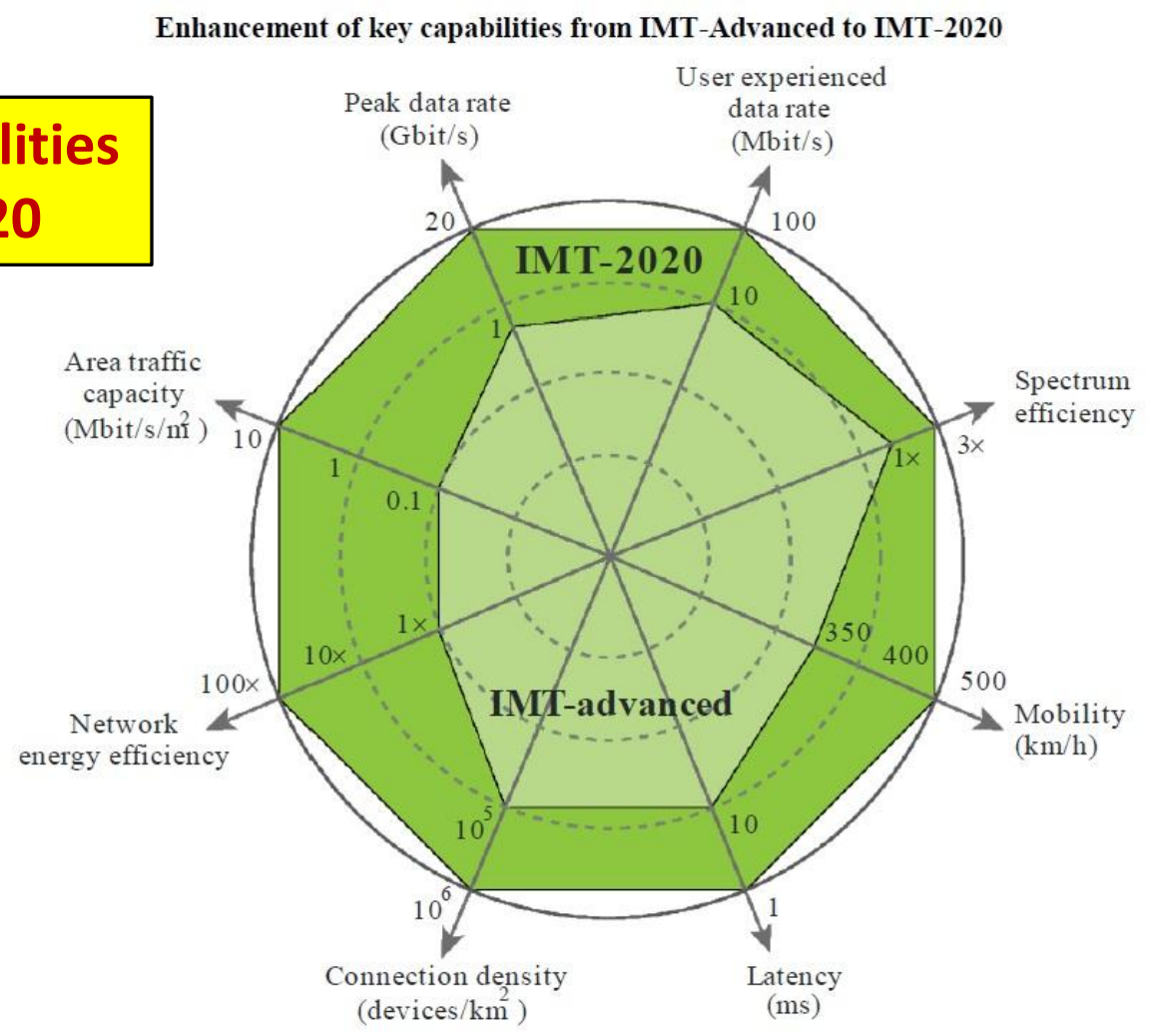
Usage Scenarios



Source : Rec. ITU-R M.2083-0

ITU's Vision for IMT-2020 (6)

Key Capabilities of IMT-2020



Source : Rec. ITU-R M.2083-0

Work of the Third Generation Partnership Project ("3GPP")

3GPP

- 3GPP is a partnership project which unites seven standards development organisations from Asia, Europe and North America

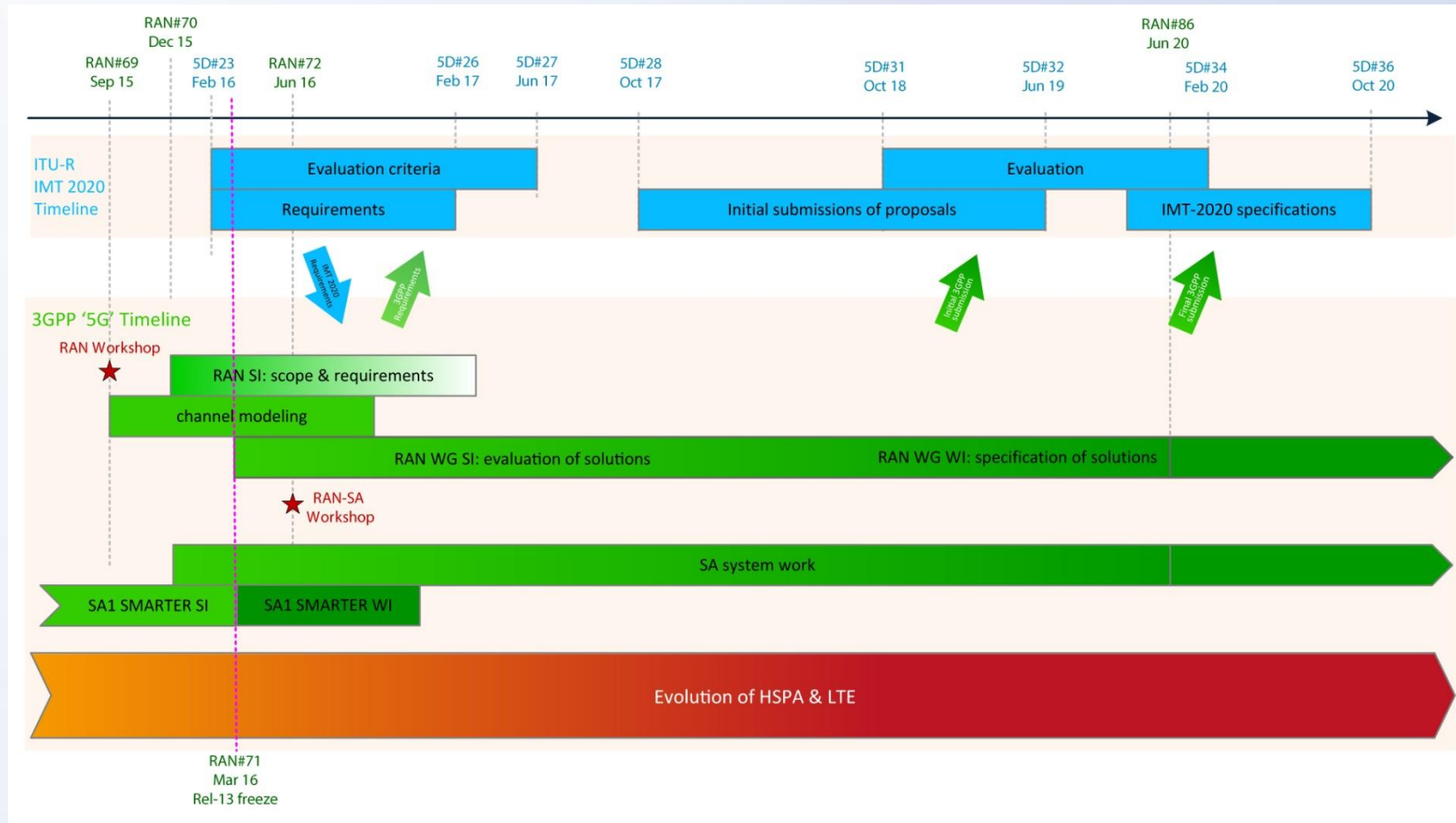


Source:
3GPP

- It provides with its members a stable environment for development reports and specifications that define 3GPP technologies and are used by the industry
- 3GPP has previously submitted candidate IMT radio access technology proposals (e.g. UTRA, LTE-Advanced) to ITU, which have been adopted as IMT standards
- 3GPP plans to submit IMT-2020 proposal to ITU

3GPP

- Tentative 3GPP Timeline for 5G



Source : 3GPP

3GPP

- **3GPP Series 38 specifications**
Radio technology beyond LTE

spec number	title
TR 38.801	TR for Study on New Radio Access Technology: Radio Access Architecture and Interface
TR 38.802	Study on New Radio Access Technology Physical Layer Aspects
TR 38.900	Study on channel model for frequency spectrum above 6 GHz
TR 38.912	Study on New Radio (NR) Access Technology
TR 38.913	Study on Scenarios and Requirements for Next Generation Access Technologies

Source : 3GPP

 **These technical reports are still under development**

5G Vision of Other Research & Development Efforts

Other Research & Development Efforts (1)



The 5G Infrastructure Public Private Partnership

- **5G PPP** is a European-based partnership initiated by the EU Commission and industry manufacturers, telecommunications operators, service providers, small and medium enterprises and researchers
- The objectives of 5G PPP are to deliver solutions, architectures, technologies and standards for the ubiquitous next generation communication infrastructures of the coming decade
- 5G PPP consists of about 20 projects working in parallel. These projects will have unique goals but together they will address the targeted 5G Key Performance Indicators and fulfil the vision of designing a new network to support ubiquitous connectivity and communications that industry and society will require in 2020

<https://5g-ppp.eu/>



- **5G Americas** is a US-based industry trade organisation composed of telecommunications service providers and manufacturers
- 5G Americas is tasked to advocate for and foster the advancement and full capabilities of LTE technology and its evolution to 5G in the Americas. It is invested in leading 5G development for the Americas region
- 5G Americas monitors and contributes to the policy considerations for mobile broadband services from government agencies in countries throughout the Americas region

<http://www.5gamericas.org/en/>

Other Research & Development Efforts (2)



- **IMT-2020 (5G) Promotion Group** was jointly established by the Chinese government bodies *MIIT, NDRC and MOST
- Members of the Promotion Group include the operators, equipment vendors, universities and research institutes in China
- It provides a platform to promote 5G technology research in China and to facilitate international cooperation.

<http://www.imt-2020.cn/en>

*MIIT – Ministry of Industry and Information Technology
NDRC – National Development and Reform Commission
MOST – Ministry of Science and Technology



- **5G Mobile Communications Promotion Forum** is a Japan-based organisation established to promote collaboration among industry, academia and government in 5G development
- The Forum is tasked to promote research and development of 5G mobile and its standardisation, information sharing, and cooperation with other related organisations

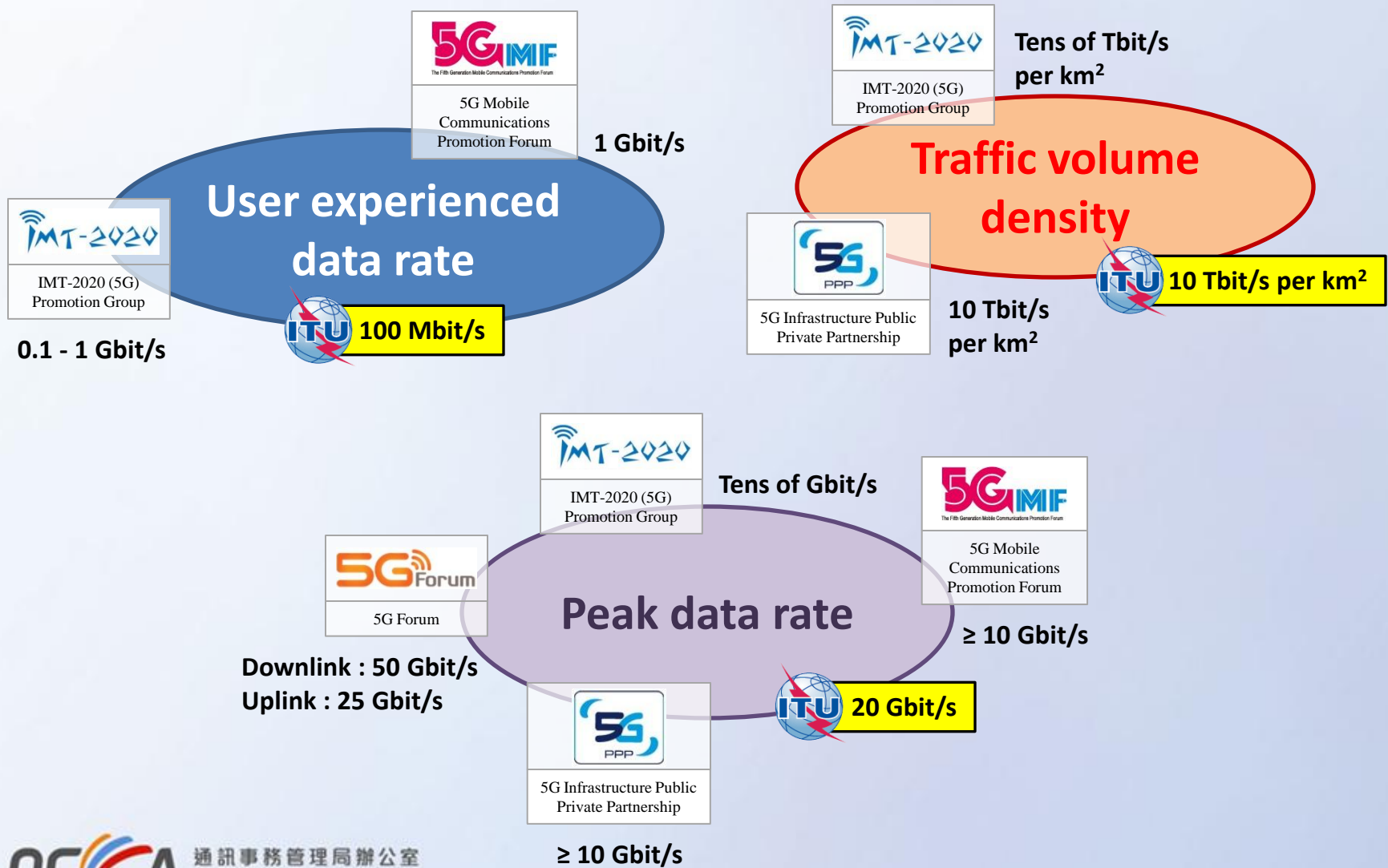
<http://5gmf.jp/en/>



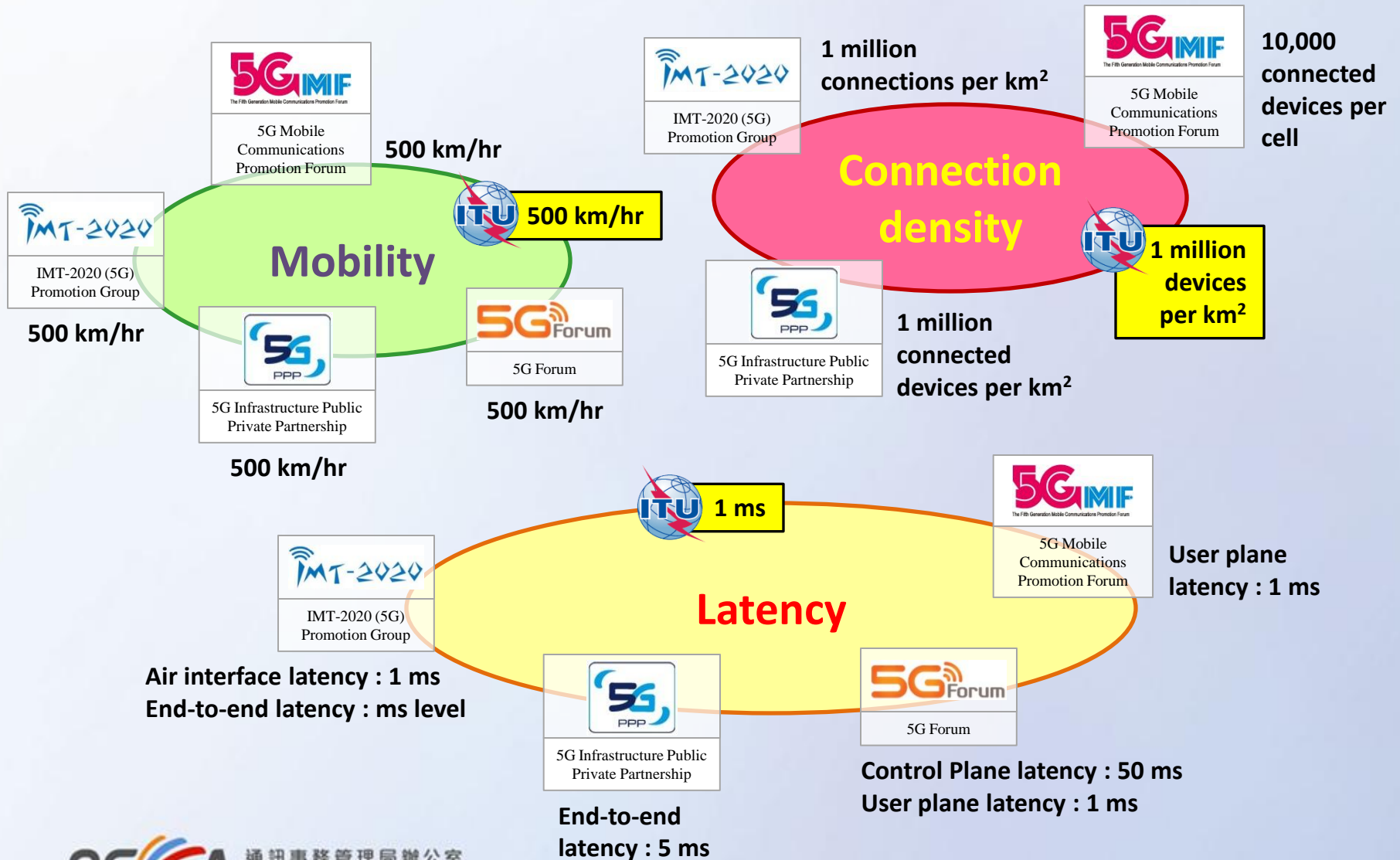
- **5G Forum** is a Korea-based forum established by the government, with members are from the public and private sectors including operators, vendors and academic professionals
- The goal of 5G Forum is to assist in the development of 5G standards and contribute to 5G globalisation

<http://www.5gforum.org/#!eng/cvb1>

5G Key Performance Indicators (1)



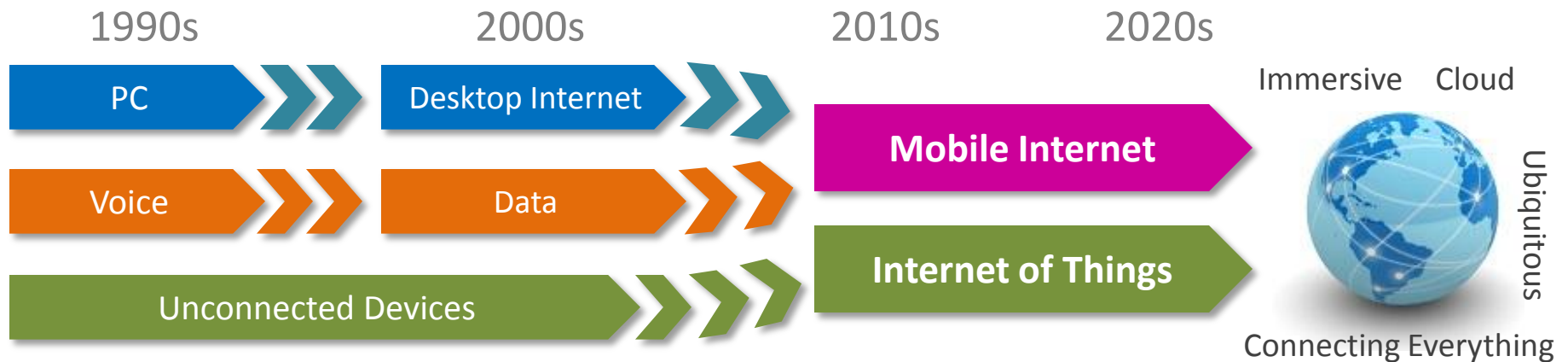
5G Key Performance Indicators (2)



5G Drivers (1)

The two major 5G drivers:

- **Mobile Internet**
- **Internet of Things (IoT)**



Source : IMT-2020 (5G) Promotion Group

5G Drivers (2)

Mobile Internet

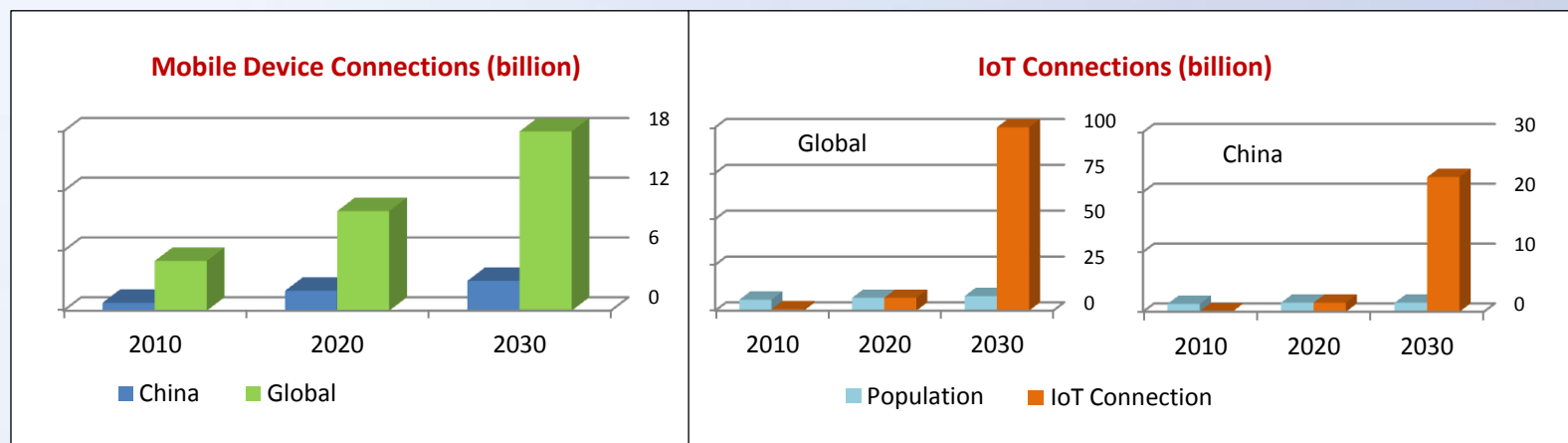
- Looking ahead to 2020 and beyond, mobile Internet can provide users with **more immersive mobile services**, e.g. augmented reality, virtual reality, ultra-high-definition 3D video, mobile cloud
- Further development of mobile Internet will trigger **thousands of times growth of mobile traffic** in the future and promote a new wave of upgrade in mobile communications technologies



5G Drivers (3)

Internet of Things (IoT)

- IoT extends mobile communications services from interpersonal communications to smart interconnection between things, and between persons and things
- Looking ahead to 2020 and beyond, there will be explosive growth in IoT applications such as mobile health, Internet of Vehicle (IoV), smart home, smart metering, environmental monitoring



Source : IMT-2020 (5G) Promotion Group

Potential 5G Technologies (1)

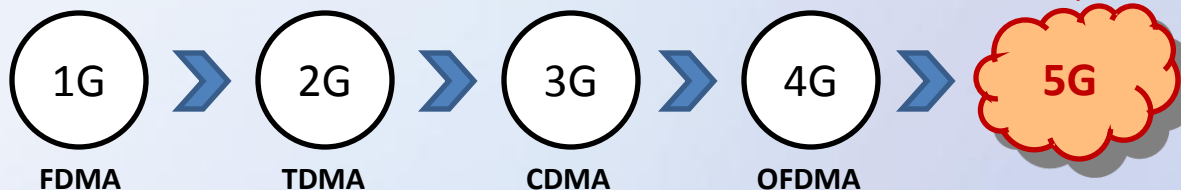
- **Novel Multiple Access**

- Improve spectral efficiency and access capability by superimposing signals of multiple users in space/time/frequency/code domains
- Several advanced multi-carrier transmission schemes are under consideration for 5G radio access, which may relax the requirement on time synchronisation to retain orthogonality:

- Filter-Bank Multi-Carrier (FBMC) transmission
- Universal Filtered Multi-Carrier (UFMC) transmission
- Generalized Frequency Division Multiplexing (GFDM)

- For rapid access of small payloads, 5G may also support non-orthogonal transmission schemes:

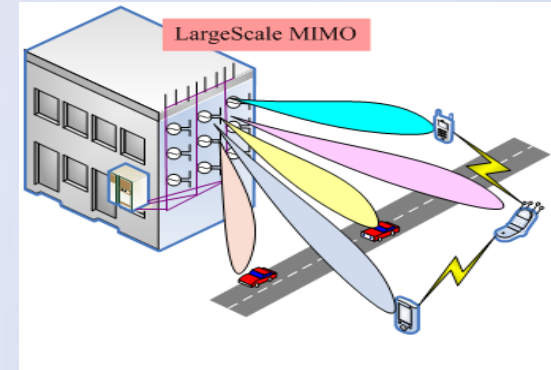
- Sparse Code Multiple Access (SCMA)
- Non-Orthogonal Multiple Access (NOMA)



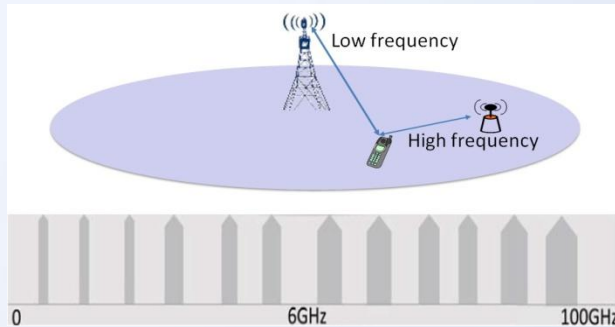
Potential 5G Technologies (2)

- **Massive MIMO**

- Allow many more antennas than 4G to support dozens of independent data streams
- Key issues to be solved include channel estimation and feedback, reference signal design, antenna array design



- **All Spectrum Access**



- Use current frequencies **below 6 GHz** with **6 GHz to 100 GHz** as supplements
- Exploit a variety of spectrum resources, including high and low bands, paired and unpaired, licensed and unlicensed, contiguous and non-contiguous

Sources : IMT-2020 (5G) Promotion Group
5G Americas

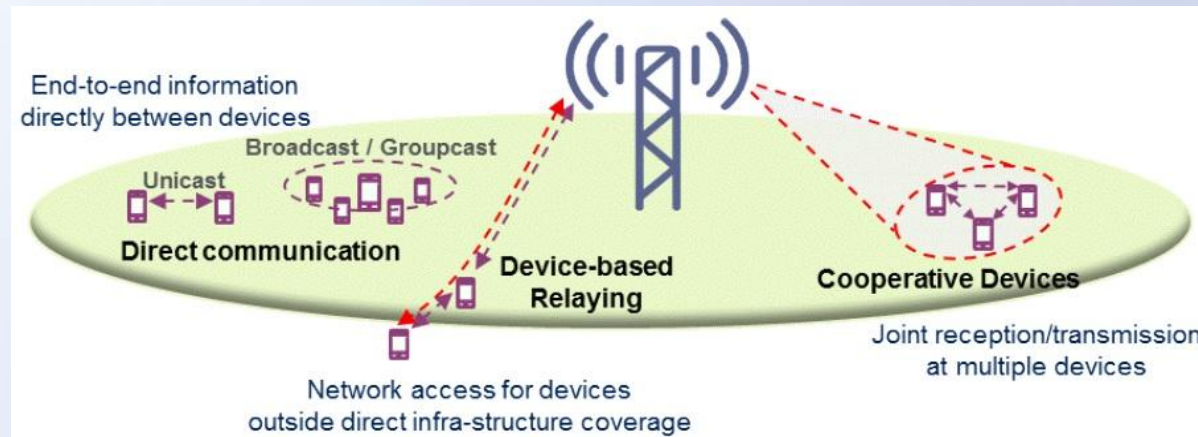
Potential 5G Technologies (3)

- **Multi-Radio Access Technology (RAT) Integration and Management**
 - It is likely that there would be multiple, heterogeneous wireless access points in ultra-dense scenarios, e.g. 5G, LTE, 3G, Wi-Fi
 - A 5G user-driven requirement is seamless user experience when moving across networks
 - The objective of this technology is to facilitate uniform multi-RAT management and convergence among disparate technologies to meet the user requirement
 - Simultaneous connection to multiple RATs may also be considered

Potential 5G Technologies (4)

- **Device-to-Device (D2D) Communication**

- Direct D2D communication considered to be a well integrated part of overall 5G wireless access solution
- Typical applications:
 - **Direct peer-to-peer D2D communication** between nearby devices to exchange end-user data
 - **Device-based relaying** : use of D2D communication to extend coverage of conventional infrastructure
 - **Cooperative devices** where high-speed inter-device communication provides means for joint transmission/reception between multiple devices




5G Spectrum being Considered by some Administrations

Frequency Bands for 5G considered by the United Kingdom

- Ofcom of the United Kingdom is considering frequency bands for 5G as identified in Resolution 238 (WRC-15) which have bandwidth wider than 1 GHz –


Frequency Bands	Bandwidth Available
24.25 – 24.75 GHz	3.25 GHz
31.8 – 33.4 GHz	1.6 GHz
37 – 43.5 GHz	6.5 GHz
45.5 – 50.2 GHz	4.7 GHz
50.4 – 52.6 GHz	2.2 GHz
66 – 76 GHz	10 GHz
81 – 86 GHz	5 GHz


-  Frequency bands of which the usage is low worldwide and receive support from all regions.

Frequency Bands for 5G considered by the United States

- The Federal Communications Commission of the United States proposes some frequency bands for 5G and are inviting comments on some others –

Proposed Frequency Bands for 5G	Frequency Bands for 5G on which comments are invited
27.5 – 28.35 GHz	24.25 – 24.45 GHz
37 – 38.6 GHz	25.05 – 25.25 GHz
38.6 – 40 GHz	29.1 – 29.25 GHz
64 – 71 GHz	31 – 31.3 GHz
	31.8 – 33 GHz
	42 – 42.5 GHz
	71 – 76 GHz
	81 – 86 GHz

 Frequency bands fall within the bands identified in Resolution 238 (WRC-15)

 Frequency bands partially fall within the bands identified in Resolution 238 (WRC-15)

Current Allocation and Use of Frequency Bands Identified in Resolution 238 (WRC-15) in Hong Kong

Frequency bands identified in Resolution 238 (WRC-15)	Existing allocations in Hong Kong (all allocations below are primary)		Existing use in Hong Kong
24.25 – 27.5 GHz	24.25 – 24.45 GHz	Radionavigation	---
	24.45 – 24.65 GHz	Fixed, Radionavigation	Fixed links
	24.65 – 24.75 GHz	Fixed	---
	24.75 – 25.25 GHz	Fixed, Fixed-satellite (E-to-sp)	Fixed links
	25.25 – 27 GHz	Fixed	Fixed links
	27 – 27.5 GHz	Fixed, Fixed-satellite (E-to-sp)	---
37 – 40.5 GHz	37 – 39.5 GHz	Fixed	Fixed links
	39.5 – 40.5 GHz	To be planned	---
42.5 – 43.5 GHz	42.5 – 43.5 GHz	To be planned	---

- Parts of the 24/26 GHz and 38 GHz bands are being used for fixed link in Hong Kong but the utilisation rate is not high (at least 76% channels are vacant).

Current Allocation and Use of Frequency Bands Identified in Resolution 238 (WRC-15) in Hong Kong

Frequency bands identified in Resolution 238 (WRC-15)	Existing allocations in Hong Kong (all allocations below are primary)		Existing use in Hong Kong
45.5 – 47 GHz	45.5 – 47 GHz	To be planned	---
47.2 – 50.2 GHz	47.2 – 50.2 GHz	To be planned	---
50.4 – 52.6 GHz	50.4 – 51.15 GHz	Fixed	---
	51.15 – 52.6 GHz	To be planned	---
66 – 76 GHz	66 – 76 GHz	To be planned	---
81 – 86 GHz	81 – 86 GHz	To be planned	---
31.8 – 33.4 GHz	31.8 – 33 GHz	To be planned	---
	33 – 33.4 GHz	Radionavigation	---
40.5 – 42.5 GHz	40.5 – 42.5 GHz	To be planned	---
47 – 47.2 GHz	47 – 47.2 GHz	Amateur, Amateur-satellite	---

Thank You