5G mobile networking – Spectrum allocation for the 20 Gbps new radio access (NR)

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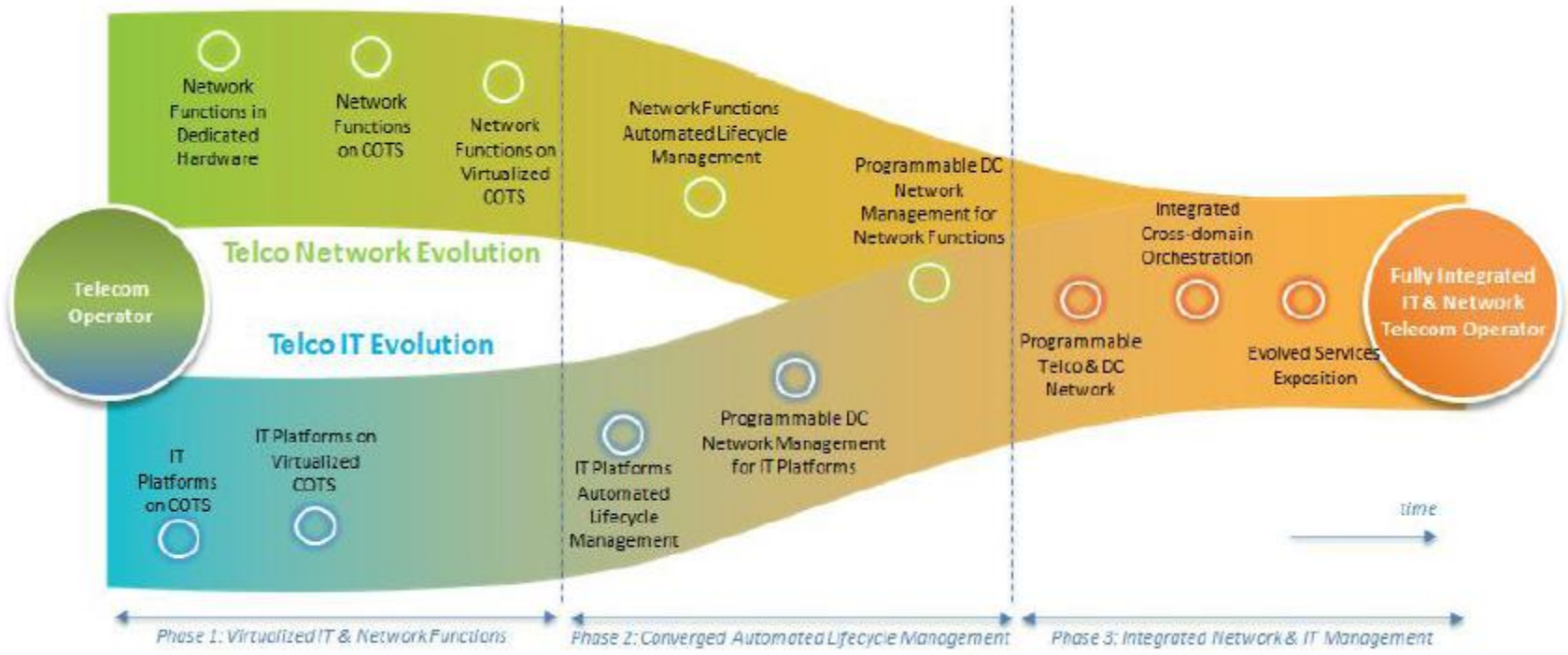
Outline

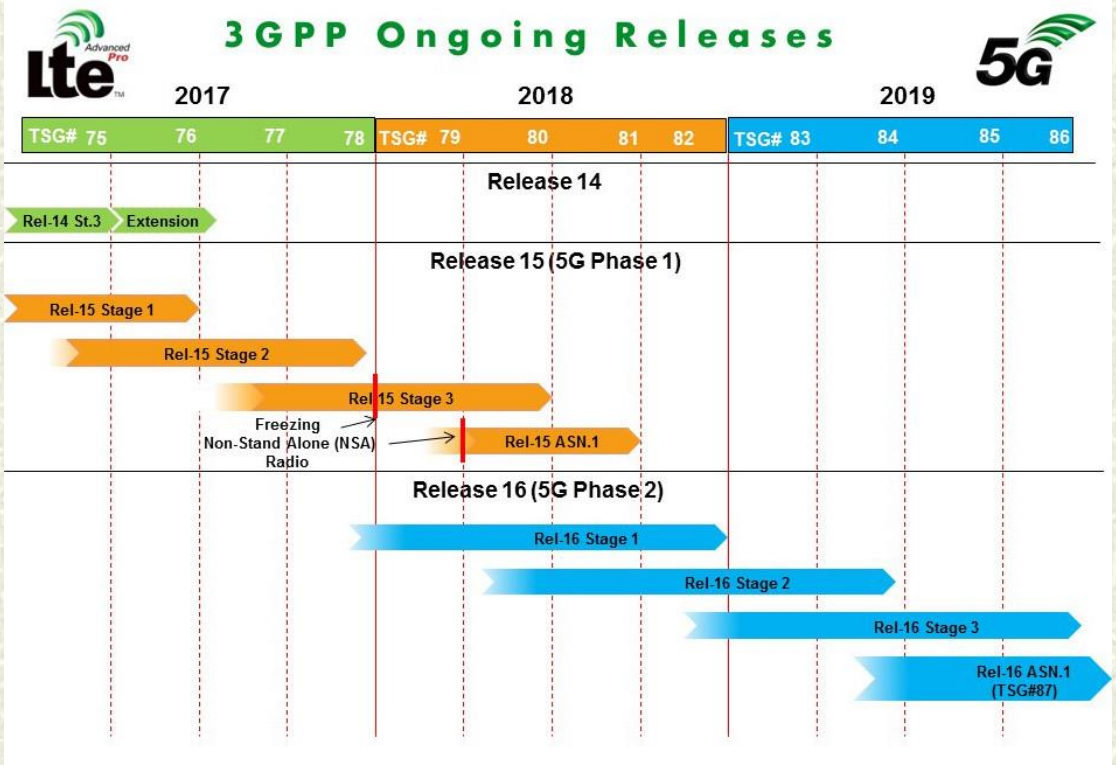
1. The convergence path of TELCOS, IT providers and broadcast services
2. 3GPP 5G standards & rollout
3. New Core (NC) and New Radio (NR) - Option architectures
4. Spectrum allocation, current initiatives & commercial deployments
5. The economics of network slicing – Microservices and lifecycle management

1. The convergence path of TELCOS, IT providers and broadcast services (1)



Towards an NFV/SDN enabled service provider

2. 3GPP 5G standards & rollout (1)



End of 2017 the non-standalone 5G access is completed. The new 5G access scheme is using dual connectivity with LTE as the master eNB and does not need a specification of a full 5G radio resource control. The standalone 5G radio access network that will be connected to the 5G core is be completed in Release 15 (mid of 2018).

2. 3GPP 5G standards & rollout (2)

Phase 1 of Release 15 includes:

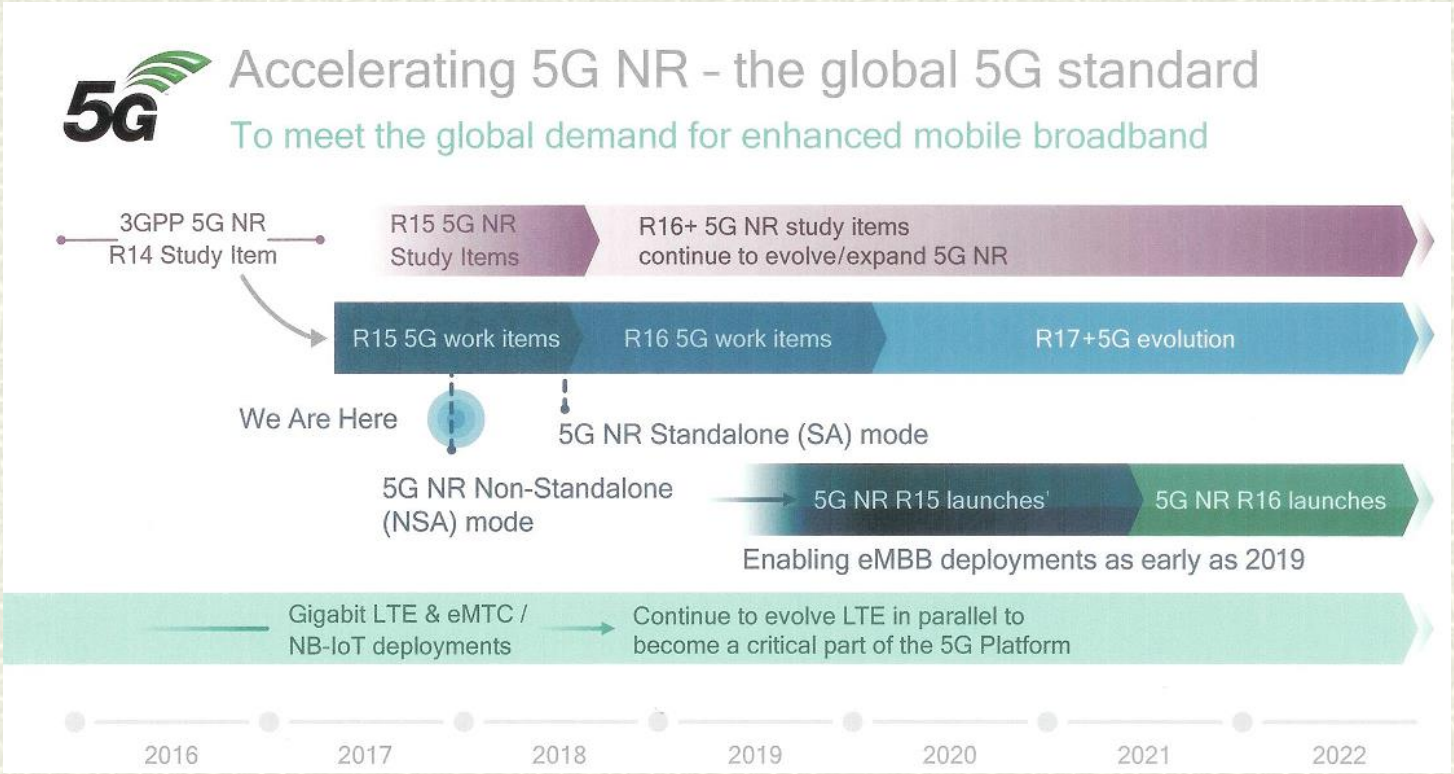
- Network Slicing support
- QoS framework
- UE/Mobility Management
- Data Session Continuity
- Efficient User Plane path
- Network Function Interaction
- Policy/Charging Control, Security
- Interworking & Migration from 4G
- Support for IMS in providing voice,
- Network discovery/selection 3GPP
- Network Capability Exposure.

Subsequent phases include:

- Broadcast/Multicast Capabilities
- Proximity Services
- Communications via Relays
- Off-Network communications
- Network discovery/selection non3GPP
- Traffic steering/switching between non3GPP accesses
- Extremely rural deployments and others.

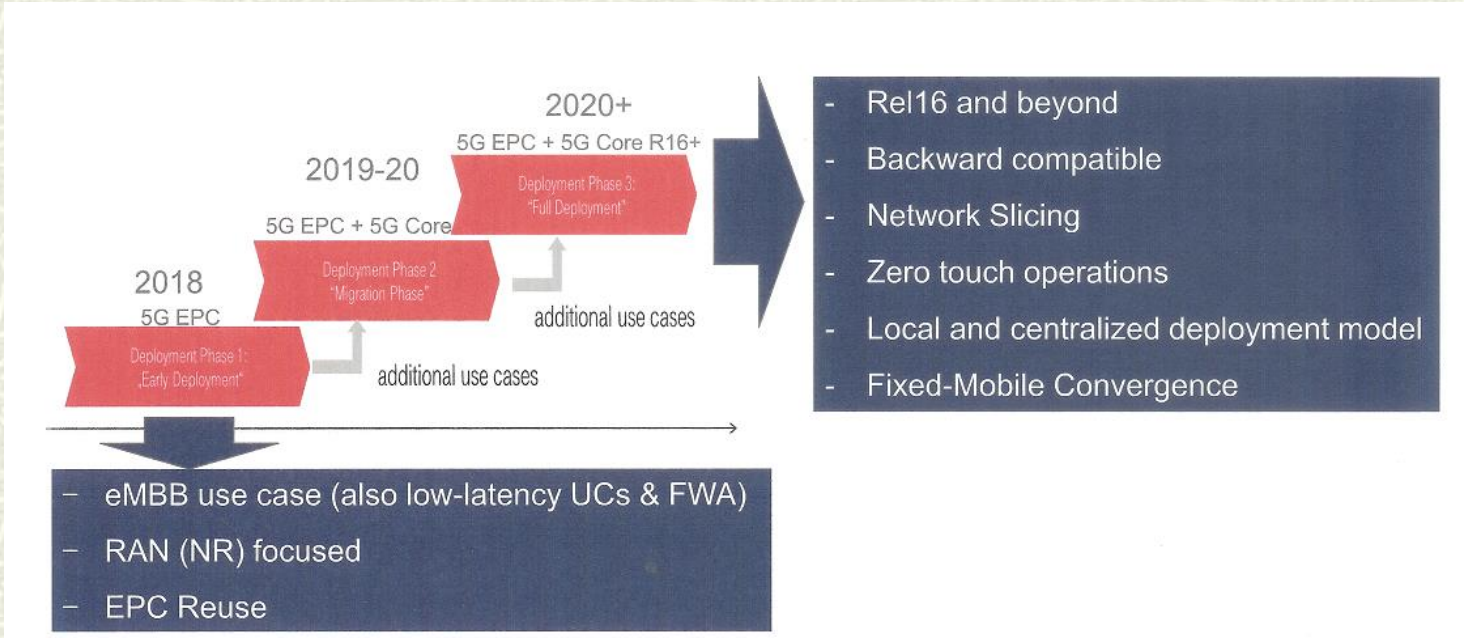
It is suggested to use NB-IoT and eMTC as baseline for 5G submission of an mMTC component. RAN standardization bodies have been discussing work items that will enhance NB-IoT and eMTC in order to fulfill the 5G requirements (one may see RP-170836 for NB-IoT and RP-170732 for eMTC). 5G can stand as standalone (Option 2 in 3GPP). There are deployment options that use both LTE and NR at the same time using dual connectivity technology (so called non-stand alone deployments). In further detail one may see *https://portal.3gpp.org/*.

2. 3GPP 5G standards & rollout (3)



New Radio rollout

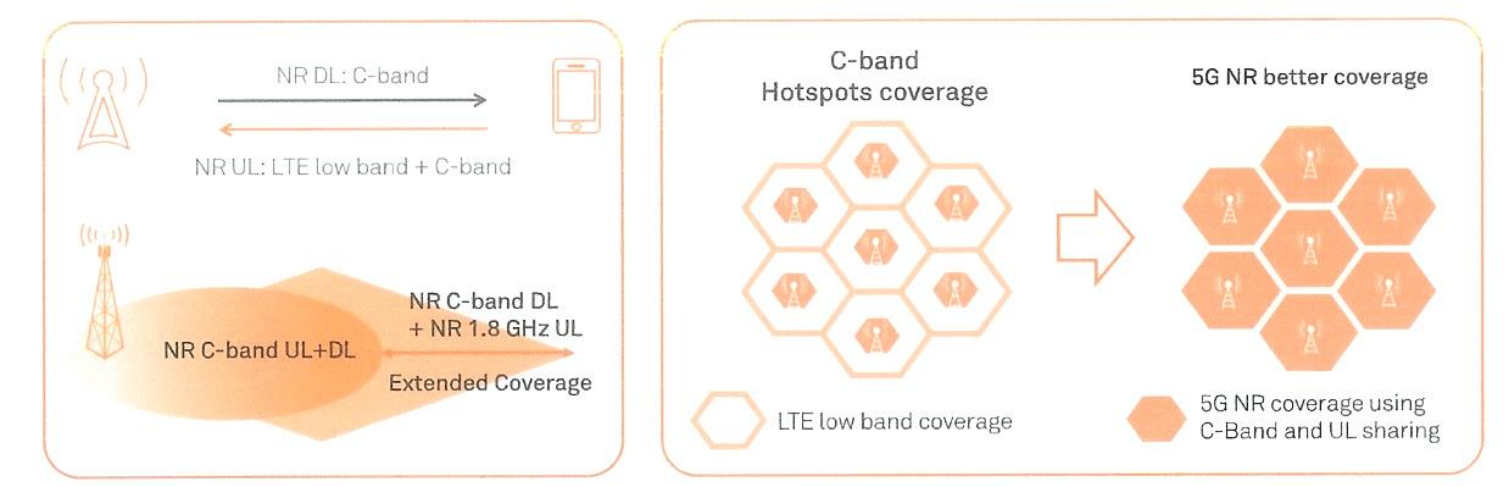
2. 3GPP 5G standards & rollout (4)



New Core rollout

2. 3GPP 5G standards & rollout (5)

LTE/NR uplink spectrum sharing C-band (3300-4200 MHz and 4400-5000 MHz)



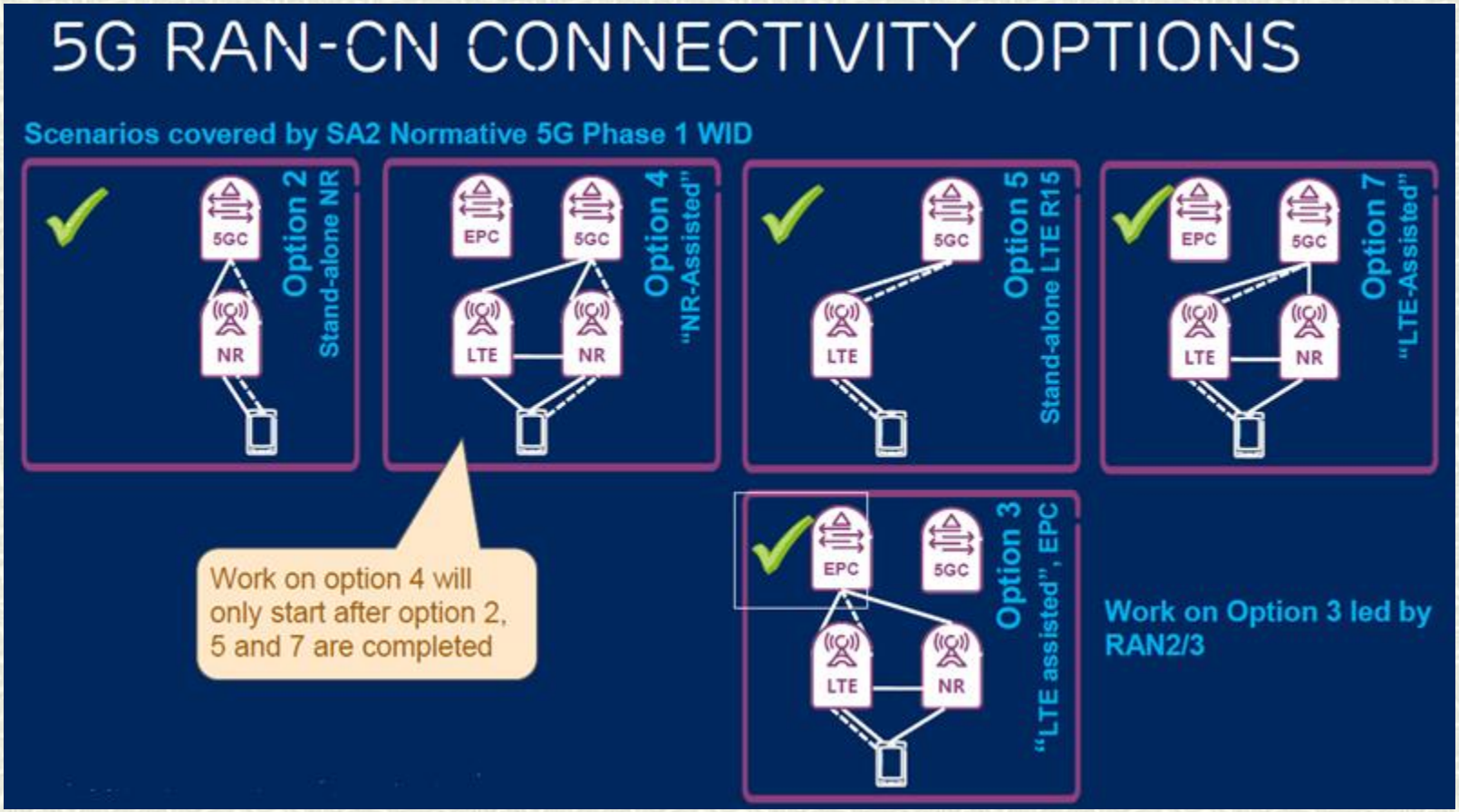
An important feature of the 3GPP Release 15 standard resides in the ability for LTE and 5G NR to co-exist and share the same low frequency bands without having to fully free those bands from LTE use. In the initial stage of 5G deployment, the new bands likely to be made available for 5G are higher in frequency (e.g. C-band) and support less sub-frames for uplink than most existing 2G/3G/4G bands. Such bands will therefore have more uplink coverage limitations compared to existing bands.

2. 3GPP 5G standards & rollout (6)

ITU-R M.2410 report (November 2017)

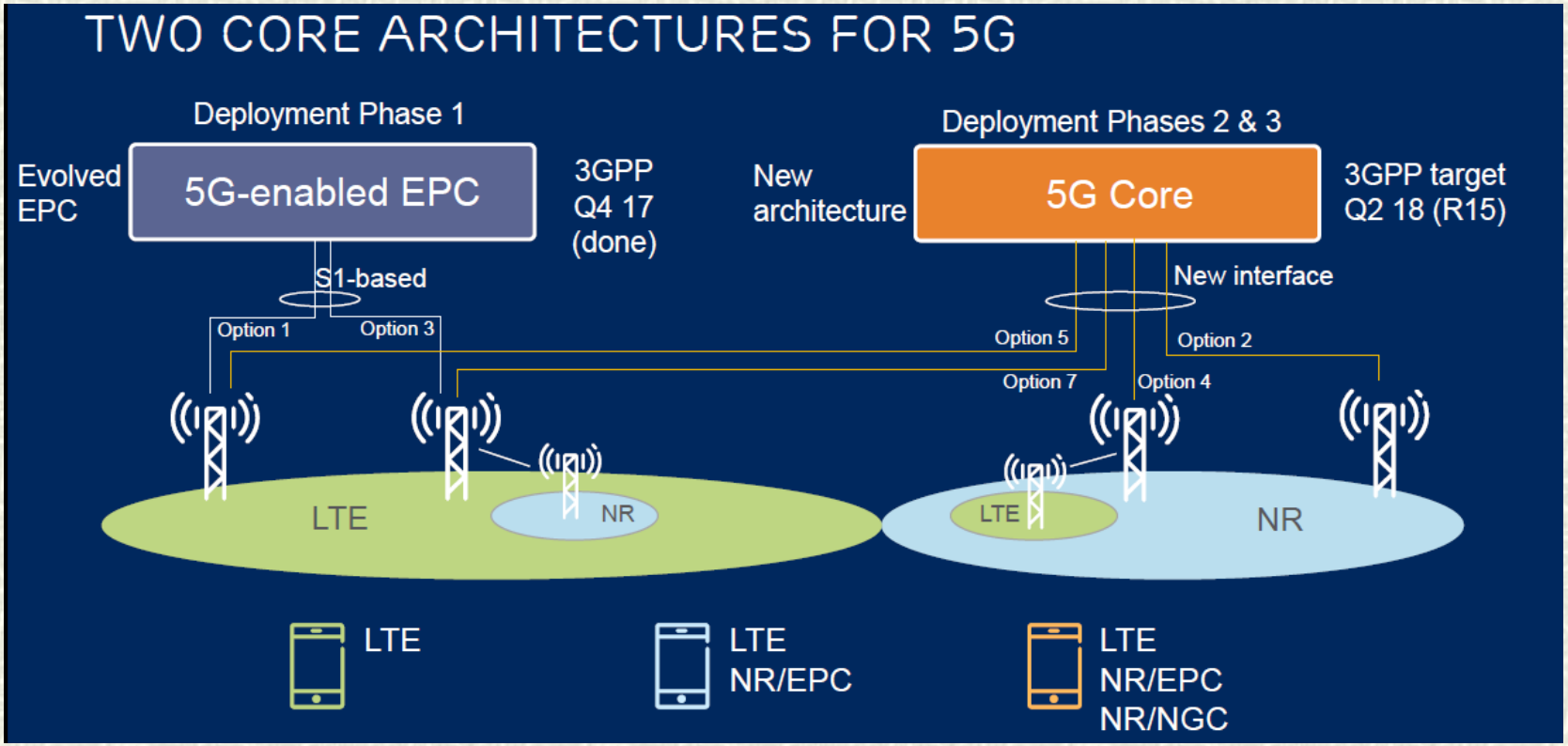
- The minimum requirements for downlink peak data rate: 20 Gbps
- The minimum requirements for uplink peak data rate: 10 Gbps
- Target downlink "user experienced data rate": 100 Mbps
- Target uplink "user experienced data rate": 50 Mbps
- Downlink peak spectral efficiency is 30 bps/Hz
- Uplink peak spectral efficiency: 15 bps/Hz
- Minimum requirement for user plane latency for eMBB: 4ms
- Minimum requirement for user plane latency for uRLLC: 1ms
- Minimum requirement for control plane latency: 20ms
- A lower control plane latency of around 10 ms is encouraged though
- Minimum requirement for connection density: 1 million devices per km^2.
- Requirement for bandwidth: at least 100 MHz
- Bandwidths up to 1 GHz are required for higher frequencies (above 6 GHz)
  - Four classes of mobility defined:
  - Stationary: 0 km/h
  - Pedestrian: 0km/h to 10 km/h
  - Vehicular: 10km/h to 120 km/h
  - High-speed vehicular: 120 km/h to 500 km/h

3. New Core (NC) and New Radio (NR) - Option architectures (1)



3. New Core (NC) and New Radio (NR) - Option architectures (2)

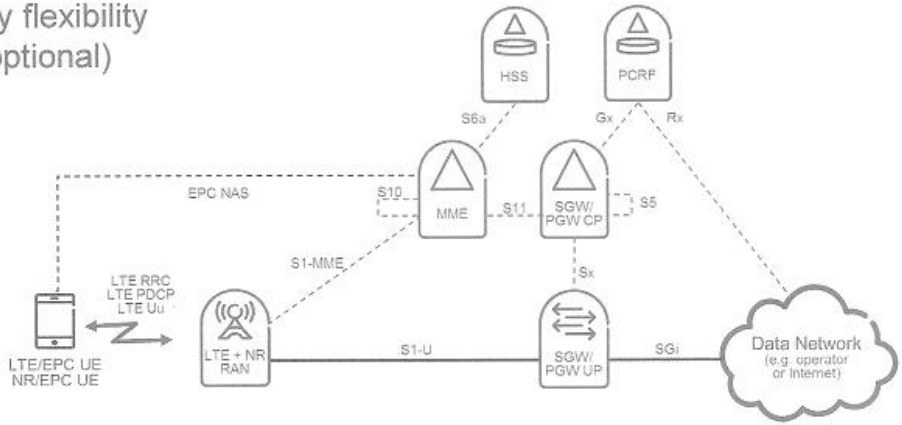
5G deployment phases



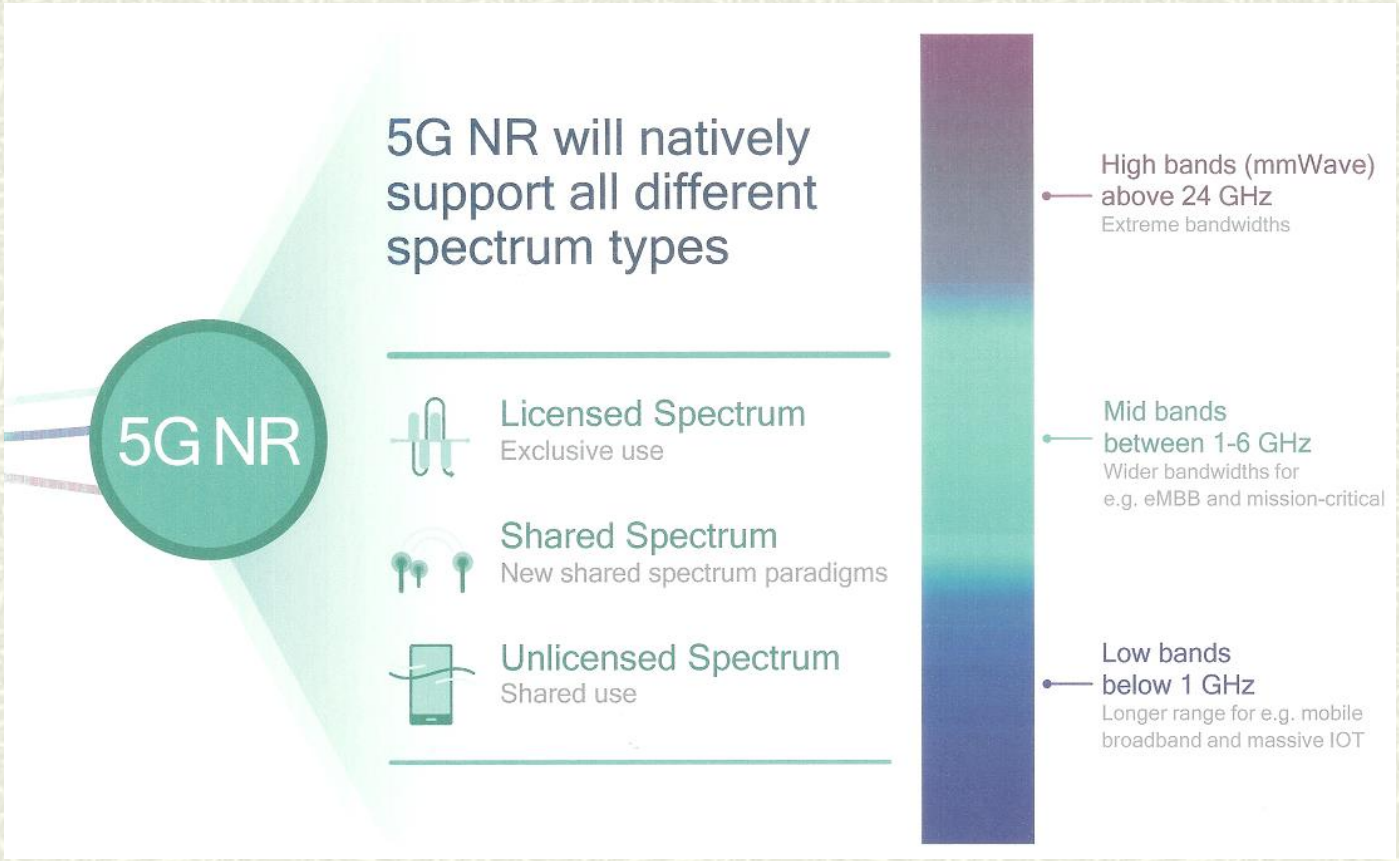
3. New Core (NC) and New Radio (NR) - Option architectures (3)

LTE-NR Dual connectivity (option 3)

- 5G Enabled SGW/PGW
  - Separation of CP and UP for maximum topology flexibility and completely independent capacity scaling (optional)
  - Support for individual high data rates for 5G
- 5G Enabled MME, HSS & PCRF
  - 5G data rate support
  - 5G subscription control
  - Dynamic mobility switching
  - Network slicing – DECOR, 5G GW selections
  - RAN volume reporting of Secondary RAT use



4. Spectrum allocation, current initiatives & commercial deployments (1)



4. Spectrum allocation, current initiatives & commercial deployments (2)

5G Spectrum in Europe

Focus on mid-band (3.4-3.8 GHz) and 26 GHz (24.25-27.5 GHz) for 2018+

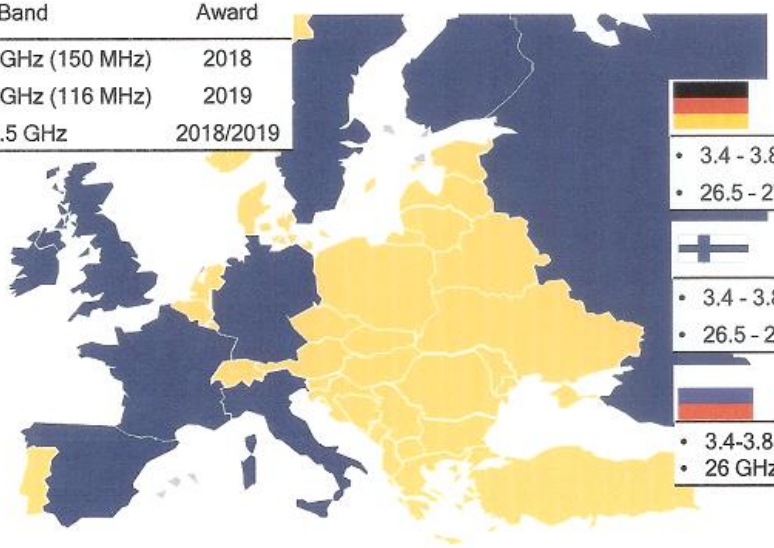
Band	Award
• 3.4 - 3.8 GHz (350 Mhz)	2017
• 26 GHz	2018

Band	Award
• 3.46 - 3.8 GHz	2018
• 26 GHz	2019

Band	Award
• 3.4-3.8 GHz	2019/2020
• 26.5 - 27.5 GHz	2019/2020

Band	Award
• 3.6 - 3.8 GHz	2018
• 26.5 - 27.5 GHz	2018

Band	Award
• 3.4 - 3.6 GHz (150 MHz)	2018
• 3.6 - 3.8 GHz (116 MHz)	2019
• 26.5 - 27.5 GHz	2018/2019



Band	Award
• 3.4 - 3.8 GHz	2018
• 26.5 - 27.5 GHz	2018?

Band	Award
• 3.4 - 3.8 GHz	2018
• 26.5 - 27.5 GHz	2020

Award	
• 3.4-3.8 GHz	2019/20*
• 26 GHz	2020+*

4. Spectrum allocation, current initiatives & commercial deployments (3)

5G spectrum in Europe

Focus on mid-band (3.4-3.8 GHz) and 26 GHz (24.25-27.5 GHz) for 2017+

EC RSC, CEPT, key European Member States are driving regulatory activities to accelerate 5G rollout in EU
Intense regulatory activities for 3.4-3.8 GHz and 26 GHz with auctions expected in 2018-2019 timeframe

- Government 5G strategy for UK published in March 2017 - DCMS and HM Treasury
- Ofcom planning to auction 150 MHz in 3.4-3.6 GHz in 2018/ 2019 - more spectrum (116MHz) in 3.6 - 3.8 GHz in 2019
- Legal Challenges might delay 3.4-3.6GHz auction to 2018 at the earliest, likelihood of a multiband auction scenario in 2019 including (700MHz, 3.4-3.8GHz and 26GHz)
- For mmWave, Ofcom has initiated a work program on 26 GHz band availability for early 5G deployment

- BenetzA planning to award 3.4-3.8 GHz in the forthcoming awarding process - expected in 2018
- For mmWave, 26.5 - 27.5GHz could be included in 2018 award

- ARCEP to award 340 MHz (3.46-3.8GHz) of spectrum in 2018; ARCEP spectrum consultation included 26 GHz

- Italian government will award 700MHz, 3.6-3.8GHz and 26.5-27.5GHz in 2018
- Multiband auction included in the country budget plan for 2018
- Major 5G trials gov't program on 100 MHz of spectrum in 3.7-3.8 GHz; discussions on re-farming 3.4-3.6 GHz between MoD, MiSE, AGCOM

- Ireland successful auction of 350 MHz of spectrum for 5G - 26GHz auction in 2018

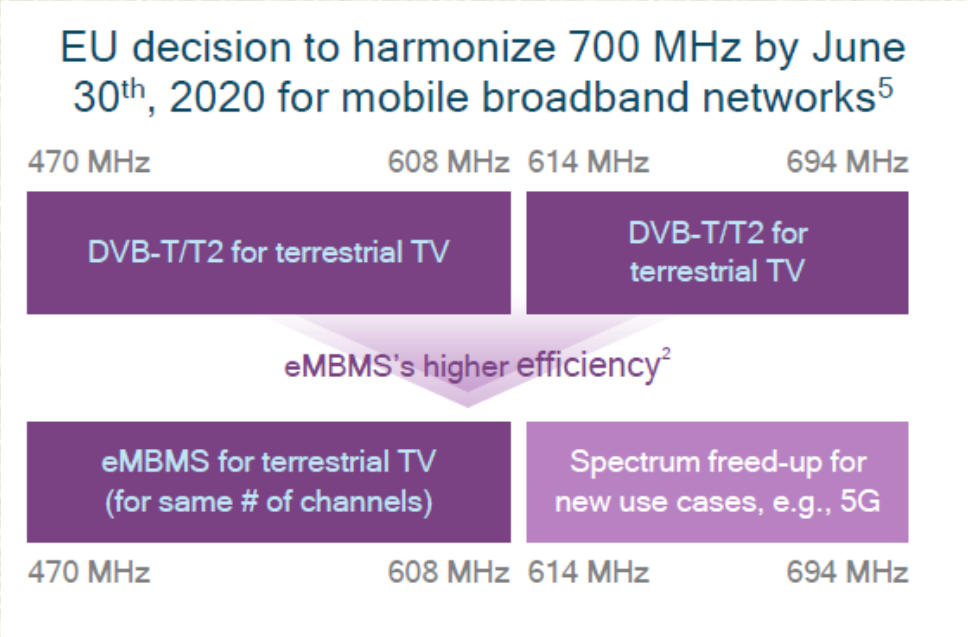
- In Spain, the 3.6-3.8 GHz band could be tendered according to market and operators needs from 2018
- Consultation ongoing on 5G Plan of Ministry for Digital Agenda; CNMC proposal to free up spectrum in the 3.4 - 3.8 GHz range
- Spain consulting on 26 GHz band - at least 1.4 GHz available for release in 2018

- Ficora is looking at "large-scale 5G tests" in 26 GHz, decided to make available up to 1 GHz for it in 2017

- PTS is looking at "large-scale 5G tests" in 26 GHz, decided to make available up to 1 GHz for it in 2017
- Commitment to make available pioneering bands by 2020 - spectrum plan expected to be announced in Q1 2018

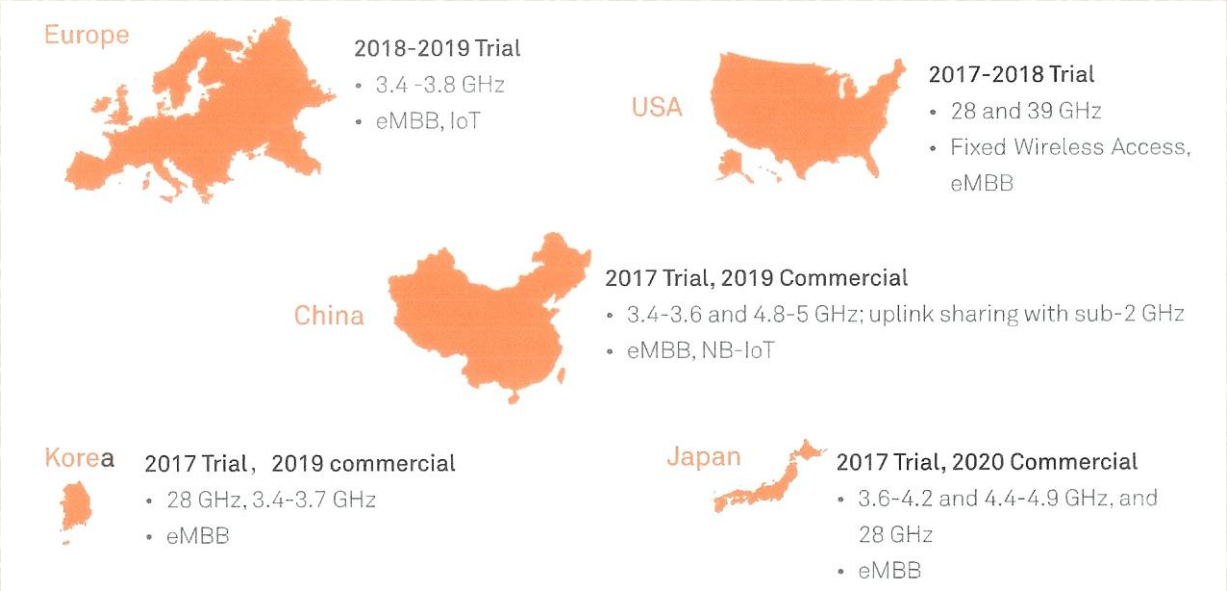
Other countries:
Belgium, Austria, Switzerland planning to release spectrum in 2018/2019 timeframe

4. Spectrum allocation, current initiatives & commercial deployments (4)



According to the Greek Regulator (EETT), a prerequisite for the development and the operation of the 5G networks in Greece is the timely and harmonized allocation of the necessary frequency bands. It is expected that within 2019 all required harmonization referring to frequency bands in 3.6GHz and 26GHz will be completed so that they will be auctioned till the end of 2020. Frequency bands in 700MHz will be allocated as well for 5G use after ending current services in these bands (UHF TV stations).

4. Spectrum allocation, current initiatives & commercial deployments (5)



Verizon started marketing 5G Home service on September 13th, 2018 with online orders. Since 2017, Verizon has been testing mmWave 5G service in 11 cities (in Ann Arbor, Atlanta, Bernardsville, Brockton, Dallas, Denver, Houston, Miami, Sacramento, Seattle, and Washington, DC.)

Nokia and T-Mobile are to roll out a nationwide 5G multi-band network in the United States using a commercial solution. Advanced radio access network (RAN) support for 4G and 5G subscribers through existing 4G LTE network is part of the solution. Building of the network is announced for the second quarter of 2018. The deployment is expected to be completing during 2020. By the end of this year, the 5G RAN will be deployed using both 600MHz and 28GHz.

4. Spectrum allocation, current initiatives & commercial deployments (6)

New bands	Supporting operators
Band n77 (3300-4200 MHz) Band n78 (3300-3800 MHz)	NTT DOCOMO, KDDI, Softbank Mobile, China Mobile, China Unicom, China Telecom, KT, SK Telecom, LG Uplus, Etisalat, Orange, Telecom Italia, British Telecom, Deutsche Telekom, Telstra
Band n79 (4400-5000 MHz)	NTT DOCOMO, KDDI, Softbank Mobile, China Mobile, China Unicom, China Telecom
Band n257 (26.5-29.5 GHz) Band n258 (24.25-27.5 GHz)	NTT DOCOMO, KDDI, Softbank Mobile, China Mobile, KT, SK Telecom, LG Uplus, Etisalat, Orange, Verizon, T-mobile, Telecom Italia, British Telecom, Deutsche Telekom, Telstra
Band n260 (37-40 GHz) *	AT&T, Verizon, T-mobile

Bands for LTE/NR uplink co-existence	Supporting operators
1710-1785MHz (UL) / 3300-3800 MHz (DL&UL)	China Telecom, China Unicom, China Mobile, Deutsche Telekom
832-862MHz (UL) / 3300-3800 MHz (DL&UL)	Orange, Telefonica, Etisalat, Deutsche Telekom
880-915MHz (UL) / 3300-3800 MHz (DL&UL)	China Mobile
703-748MHz (UL) / 3300-3800 MHz (DL&UL)	Orange, Telefonica, Etisalat
1920-1980MHz (UL) / 3300-3800 MHz (DL&UL)	China Telecom
2496-2690MHz (TDD UL) / 3300-3800 MHz (DL&UL)	China Telecom

4. Spectrum allocation, current initiatives & commercial deployments (7)

Germany, 700 MHz (mobile broadband, 2015, with spectrum available from 2019)

Spain, 3.5 GHz (mobile broadband services, 2016, Orange a 80 MHz spectrum)

USA, 600 MHz (technology neutral, 2017) and 28 GHz, 39 GHz (mobile use, 1999–2006)

Greece, 24.5–26.5 GHz (Free Wireless Access, 2017, a renewal of a license first granted in 2000)

Ireland 3.5GHz/3.7GHz spectrum sale by ComReg in May 2017 with five companies laying claim to a total of 350MHz of bandwidth on offer (Imagine Communications, Airspan Spectrum Holdings, Vodafone, Three Ireland Hutchison Ltd & Meteor Mobile Communications)

Czech Republic, 3600–3800 MHz (high-speed mobile data services, July 2017, O2 Czech Republic a.s., Vodafone Czech Republic a.s., Nordic Telecom 5G a.s. and PODA a.s)

Norway, 900 MHz (mobile services, 2017)

Saudi Arabia, 700 MHz, 800 MHz, 1800 MHz (next generation wireless high-speed data services, 2018)

Tanzania, 700 MHz (ICT services, 2018)

Ofcom's first 5G spectrum auction (**UK**) was completed in April 2018, with EE, O2, Vodafone and Three all winning some spectrum.

Spain's auction of 5G spectrum (July 2018) has raised about €438 million for the government with Telefónica, Orange and Vodafone dividing the airwaves. The new Spanish licenses cover the spectrum between 3.6 GHz and 3.8 GHz (40 blocks of 5 MHz)

5G auction in **Italy** in October 2018 for 3.7 GHz spectrum raises a total of €6.5bn (paid by Vodafone Italia and Telecom Italia).

The FCC in USA will hold its first 5G spectrum auctions on November 14, 2018, for the 28 GHz and the 24 GHz bands. A total of **seventeen countries have formally announced plans to auction 5G spectrum between 2018-19**

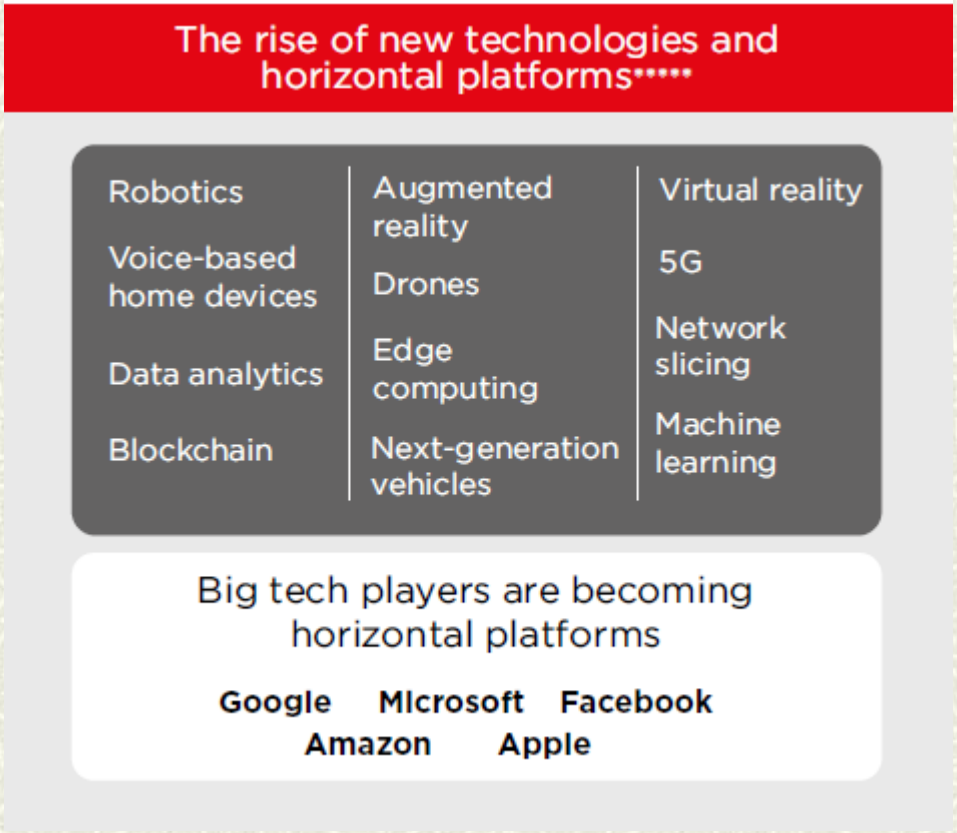
4. Spectrum allocation, current initiatives & commercial deployments (8)

- It is expected that most operators will introduce 5G from 2020, which is closely linked to the timeline for 5G standardization.
- Early deployments of pre-standard networks are anticipated in selected markets. As of today, there are around 30 operators that have publicly announced 5G introduction plans, with several trials already taking place.
- Rollout is expected to commence in metropolitan and urban areas, and is forecast to reach around 10 percent population coverage by 2022.

5. The economics of network slicing – Microservices and lifecycle management (1)

Mobile ecosystem trends

Network slicing is one of the most promising options; this would involve an operator reserving defined segments, or slices, of network capacity for a particular customer (e.g. a factory using advanced robotics) at a guaranteed quality of service. For example, operators can separate one network slice to carry the connectivity for a corporate training program with agreed data traffic capacity, and another slice for a connected car manufacturer with higher requirements in terms of latency and security.



5. The economics of network slicing – Microservices and lifecycle management (1)

The microservices architecture is an alternative to the monolithic architecture and supports slicing and virtualization

The term "Microservices" was introduced by Dr. Peter Rodgers during a presentation at Cloud Computing Expo in 2005. Microservices refer to software components implementing Micro-Web-Services. They are a more concrete and modern interpretation of Service-Oriented Architectures (SOA) used to build distributed software systems. Like in SOA, services in a microservice architecture are processes that communicate with each other over the network in order to fulfill a goal. Microservices architectural style is a first realization of SOA after the introduction of DevOps for building continuously deployed systems.

In a microservices architecture, services should be small and the protocols should be lightweight. The benefit of distributing different responsibilities of the system into different smaller services is that it enhances the cohesion and decreases the coupling. This makes it much easier to change and add functions and qualities to the system anytime. It also allows the architecture of an individual service to emerge through continuous refactoring, hence reduces the need for a big up-front design and allows for releasing the software early and continuously.

5. The economics of network slicing – Microservices and lifecycle management (2)

Commercial benefits

- ***Reducing Cost:*** Through providing the opportunity to consolidate redundant application functionality and decouple functionality from obsolete and increasingly costly applications while leveraging existing investments.
- ***Agility:*** Structure business solutions based on a set of business and IT services in such as way as to facilitate the rapid restructuring and reconfiguration of the business processes and solutions that consume them.
- ***Increasing Competitive Advantage:*** Provide the opportunity to enter into new markets and leverage existing business capabilities in new and innovative ways using a set of loosely-coupled IT services. Potentially increase market share and business value by offering new and better business services.
- ***Time-to-Market:*** Deliver business-aligned solutions faster by allowing the business to decide on the key drivers of a solution and allowing IT to rapidly support and implement that direction.
- ***Consolidation:*** Integrate across silo'ed solutions and organizations, reduce the physical number of systems, and enable consolidation of platforms under a program of "graceful transition" from legacy spaghetti dependencies to a more organized and integrated set of coexisting systems.
- ***Alignment:*** SOA enables organizations to better align IT to business goals, enabling the business to associate IT with capabilities that an organization wants to achieve in alignment with its strategic plan, leading to both sustained agility and re-use over time.


Thank you