5G Standards

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What is 5G?

- **5th-Generation Wireless Systems** (abbreviated **5G**) is the marketing term for technologies that satisfy ITU IMT-2020 requirements and 3GPP Release 15.
- Key features of 5G include high throughput, low latency, high spectral efficiency, high mobility and high connection density.
- 5G will enable a significant increase in the amount of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology.
- 5G will enable dramatic increase of different types of new services and applications.

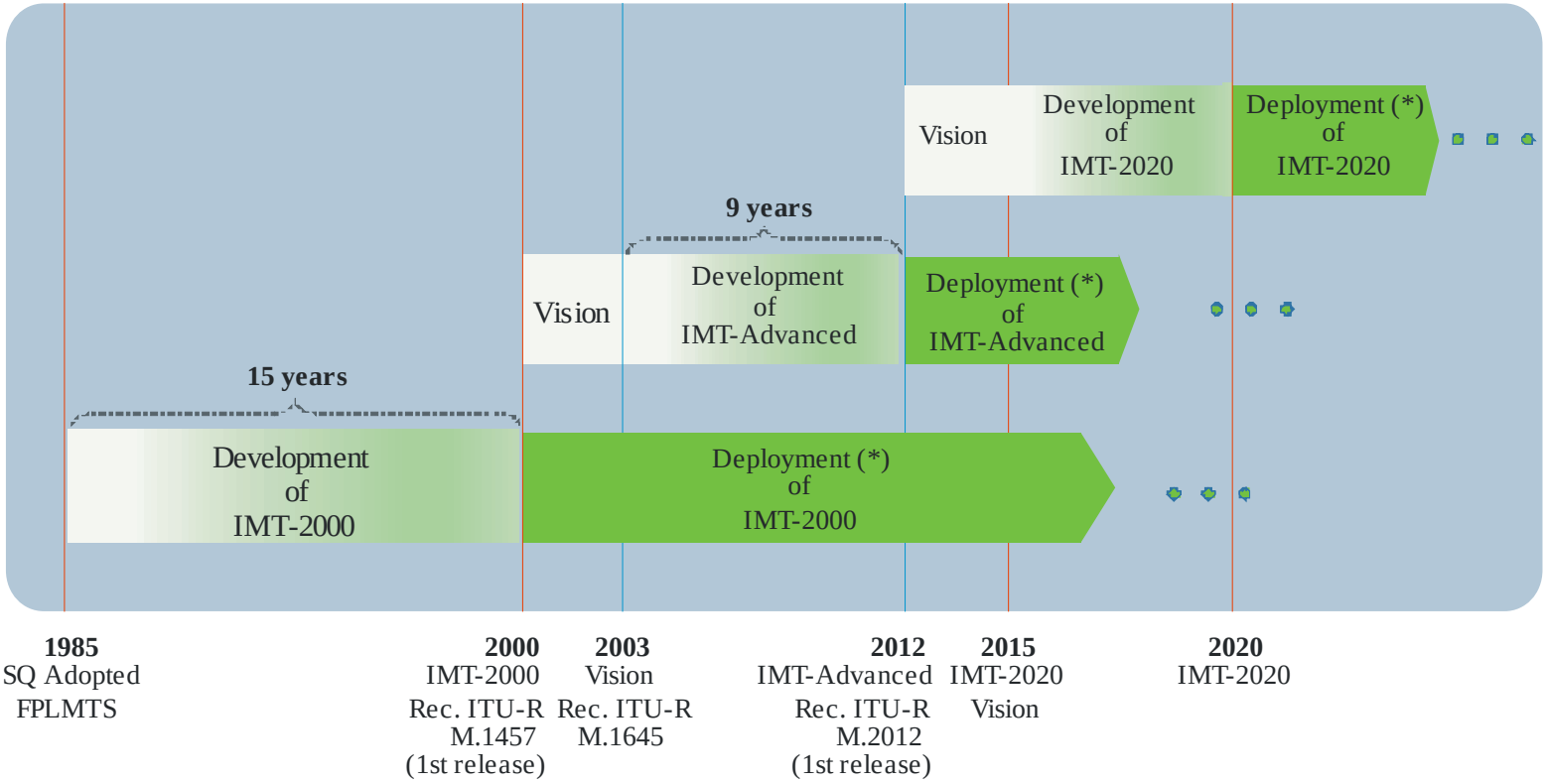
5G Services

Source: Qualcomm

5G Standards

- 5G standards are developed in the 3rd Generation Partnership Project (3GPP), ITU Radiocommunication Sector (ITU-R), ITU Telecommunication Standardization Sector (ITU-T), the Internet Engineering Task Force (IETF) and IEEE.
- Here we focus on activities within 3GPP and ITU.
- ITU-R SG5 WP 5D is responsible for the overall radio system aspects of International Mobile Telecommunications (IMT) systems, comprising the IMT-2000, IMT-Advanced and IMT for 2020 and beyond.
- Activities are also going on in most ITU-T Study Groups
- ITU-T SG13: Future networks, with focus on IMT-2020, cloud computing and trusted network infrastructures.

Timeline for IMT development and deployment

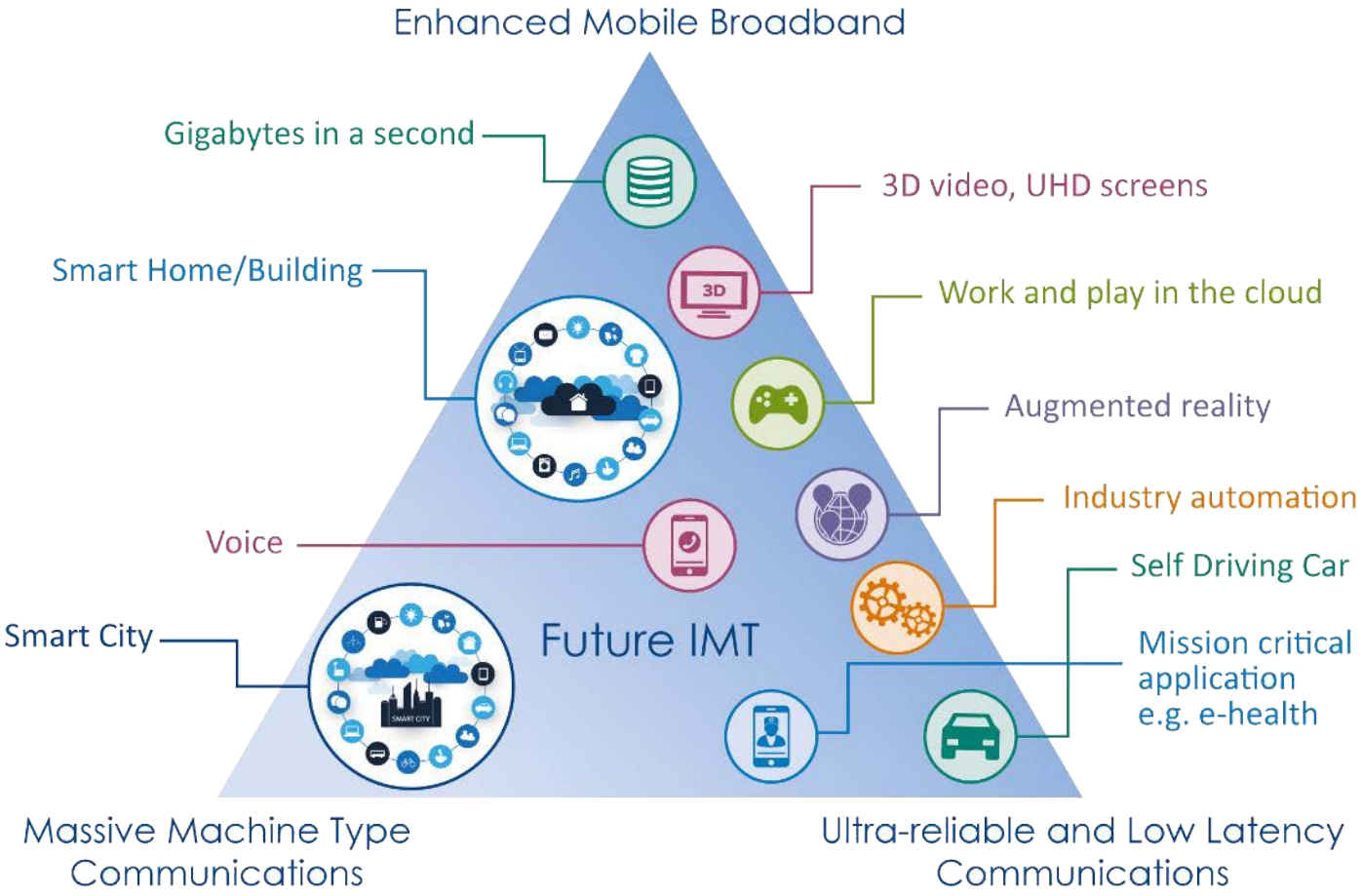


Source ITU-R REC M.2083

ITU IMT-2020

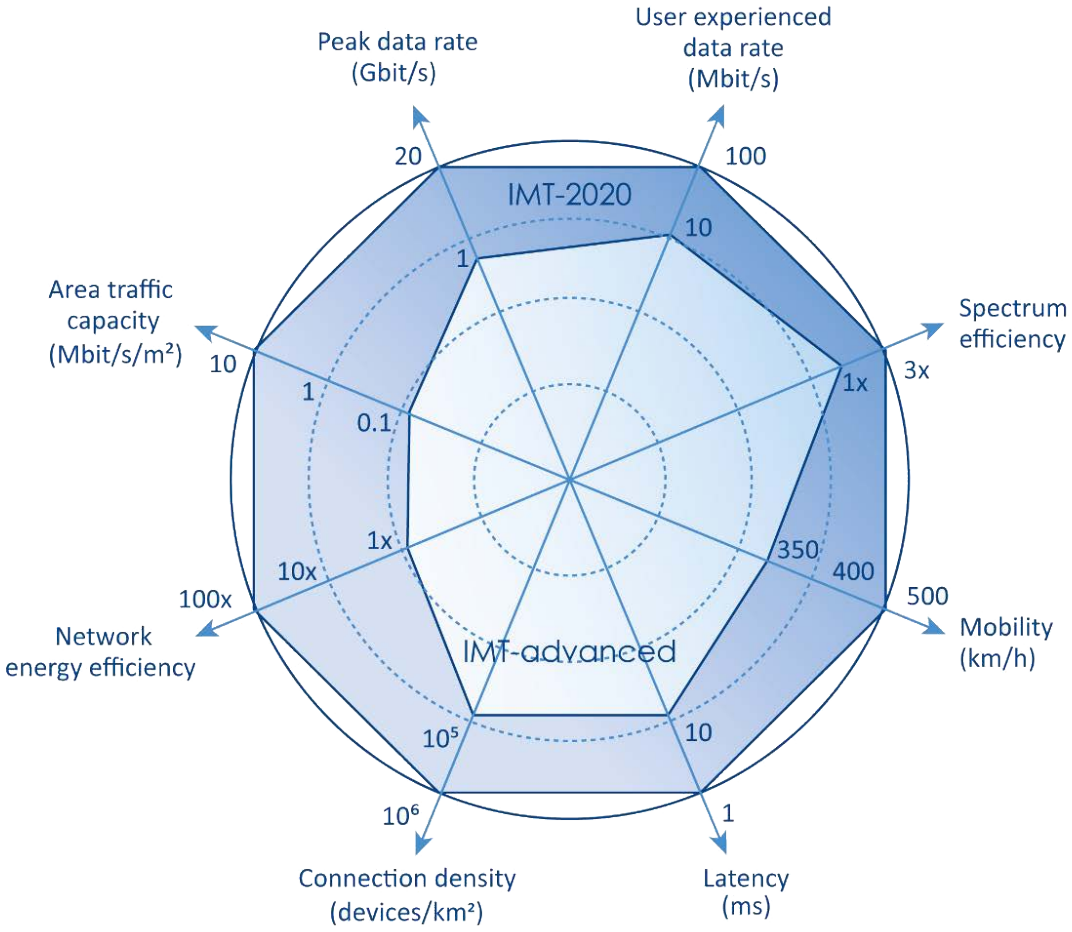
- As defined in Resolution ITU-R 56-2, International Mobile Telecommunications-2020 (IMT-2020) systems are mobile systems that include new radio interface(s) which support the new capabilities of systems beyond IMT-2000 and IMT-Advanced.
- In Recommendation ITU-R M.2083 “IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond”, the capabilities of IMT-2020 are identified, which aim to make IMT-2020 more flexible, reliable and secure than previous IMT when providing diverse services in the intended three usage scenarios, including enhanced mobile broadband (eMBB), ultra-reliable and low-latency communications (URLLC), and massive machine type communications (mMTC).

Usage scenarios of IMT for 2020 and beyond



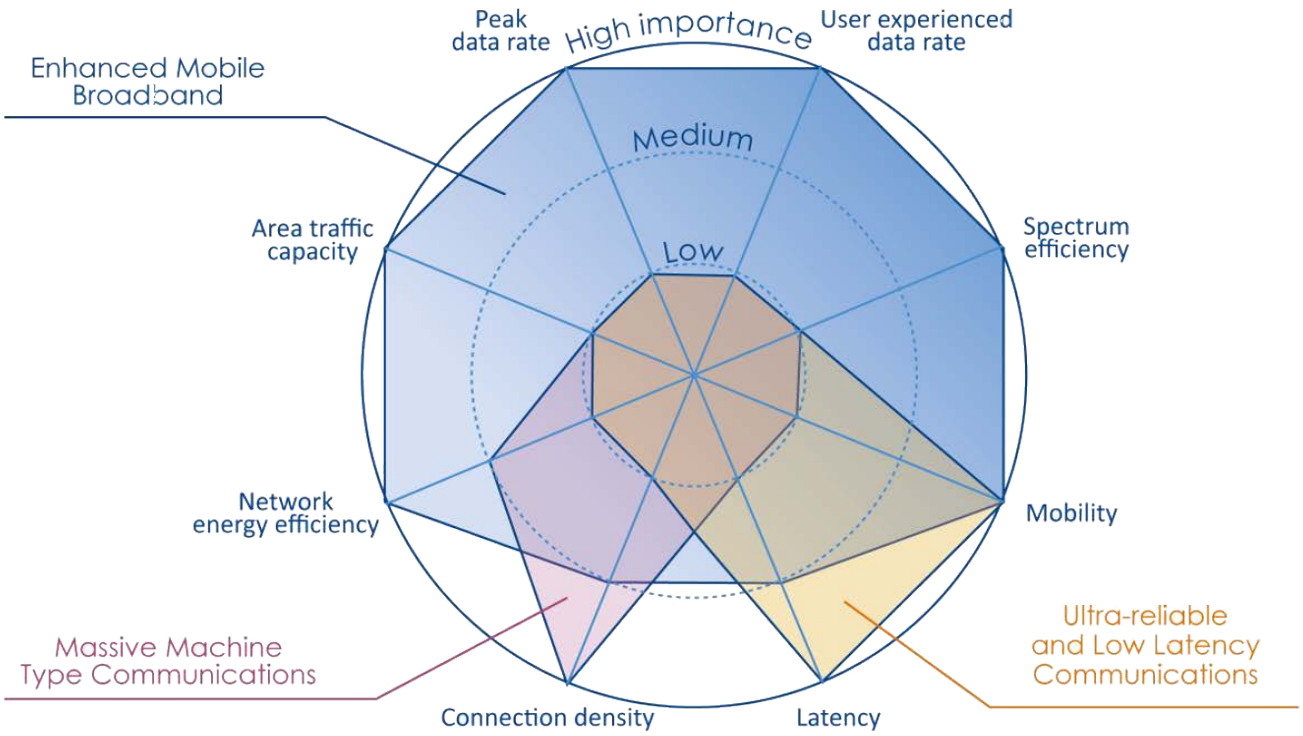
Source ITU-R REC M.2083

Enhancement of key capabilities from IMT-Advanced to IMT-2020



Source ITU-R REC M.2083

The importance of key capabilities in different usage scenarios



Source ITU-R REC M.2083

ITU Requirements

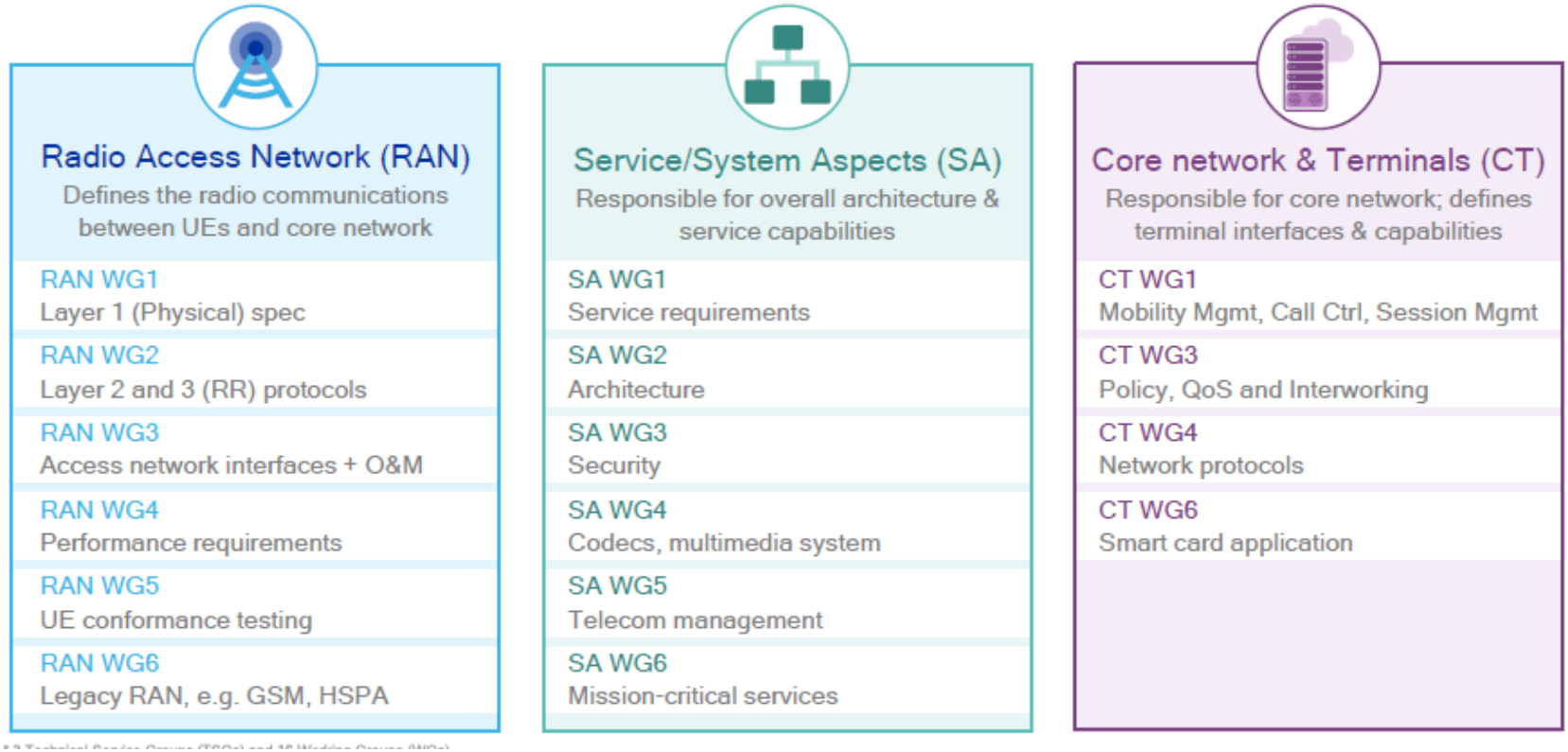
- In November 2017 the ITU released the “Minimum requirements related to technical performance for IMT-2020 radio interface(s)” – Report M.2410.
- 8 requirements are based on the key capabilities in ITU-R Rec. M.2083.
- 5 additional requirements are added: peak spectral efficiency, 5th percentile spectral efficiency, reliability, mobility interruption time, bandwidth.
- The minimum downlink peak data rate of 5G technologies needs to amount to 20 Gbit/s, while the uplink rate must reach at least 10 Gbit/s.
- Downlink peak spectral efficiency of 30 bit/s/Hz, while their uplink peak spectral efficiency needs to be at least half of that.
- The downlink data rate experienced by the end user must be at least 100 Mbit/s, while the uplink rate shouldn’t fall under 50 Mbit/s.
- A minimum of one million connected devices for each square kilometer.
- A latency that isn’t higher than 4ms, or 1ms for URLLC that will likely be used for critical systems like medical solutions and some connected car systems.

3GPP

- 3GPP is a partnership of seven regional Standard Setting Organizations (SSOs).
- Formed to create and maintain global wireless Technical Specifications to be transposed into communication standards.

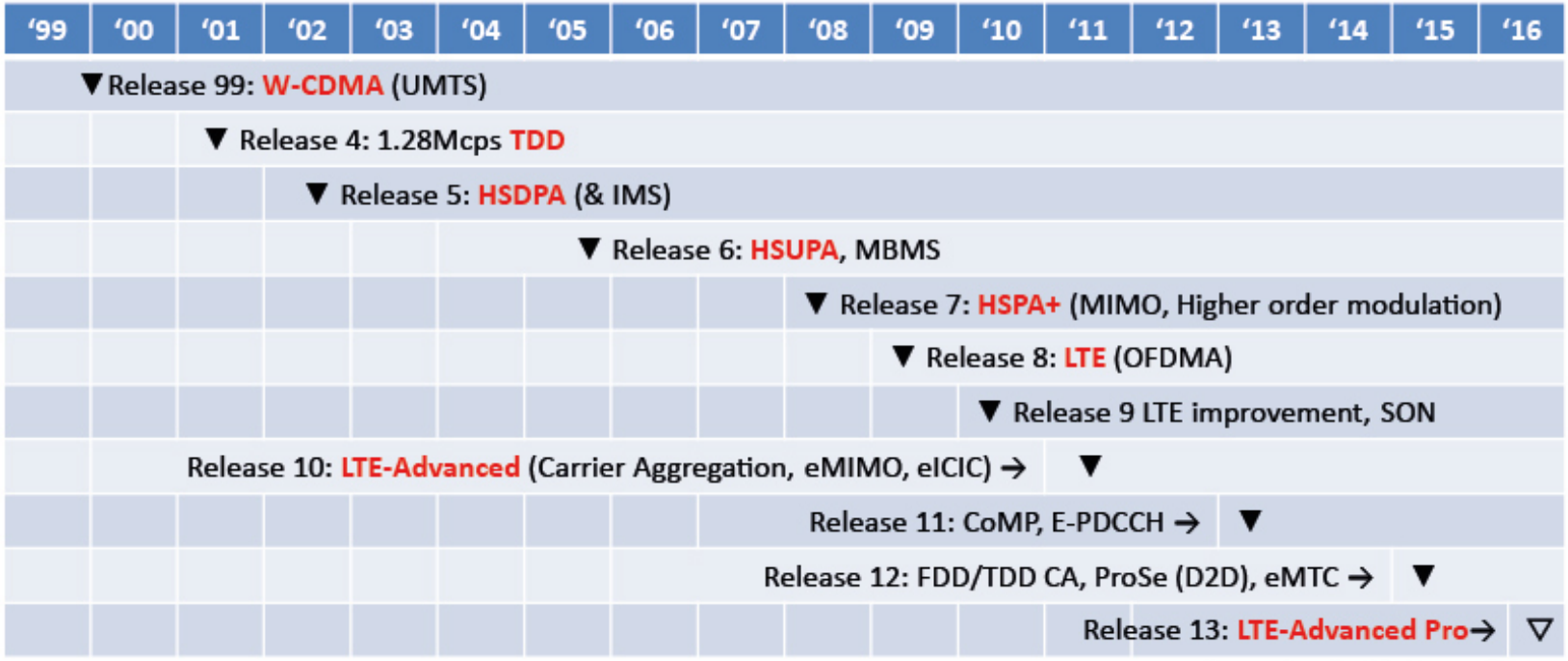
3GPP Organization

- Technical work occurs across 3 Technical Specification Groups (TSGs) and 16 Working Groups (WGs).



3GPP Releases

3GPP uses a system of parallel "Releases" which provide developers with a stable platform for the implementation of features at a given point and then allow for the addition of new functionality in subsequent Releases.

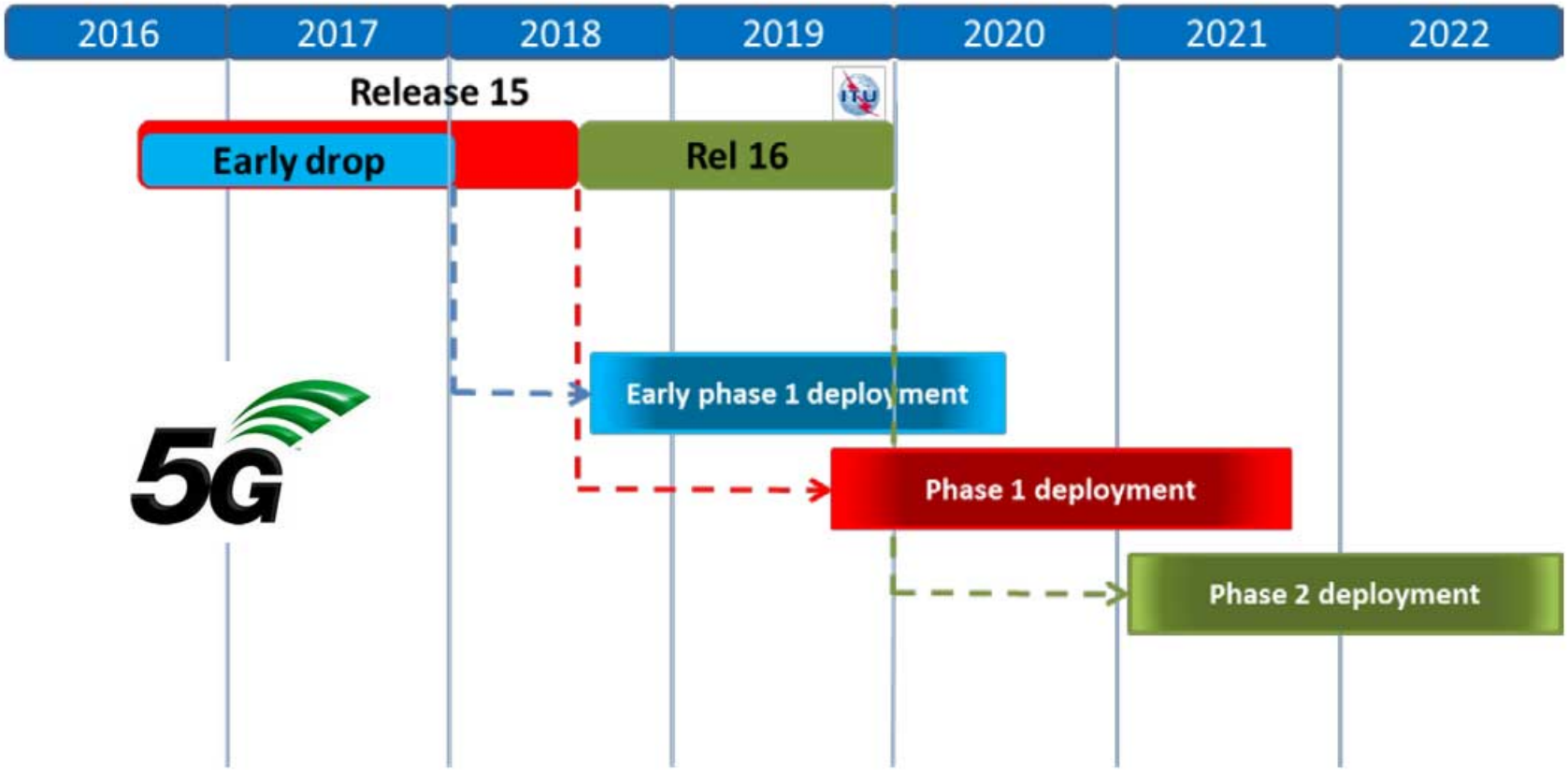


Source 3GPP

3GPP 5G

- 3GPP 5G will expand the LTE platform for new services, while improving its efficiency to meet the mobile broadband demand
- 3GPP 5G is not only a new radio (NR) interface, but a full system, integrating LTE and NR radio access technologies with a 5G Core Network
- Initially some of the use cases will be fulfilled by LTE, but the aim is to eventually fulfil all the requirements with NR
- From Release 15 onwards, the 3GPP specifications (LTE, NR and Core Network) will be marked “5G”
- 5G expands offerings by specializing radio and network capabilities (vertical sectors):
  - Enhanced Mobile Broadband
  - Massive Internet of Things
  - Ultra-Reliable & Low Latency

3GPP 5G Timeline



Source 3GPP

Recent 3GPP 5G Developments

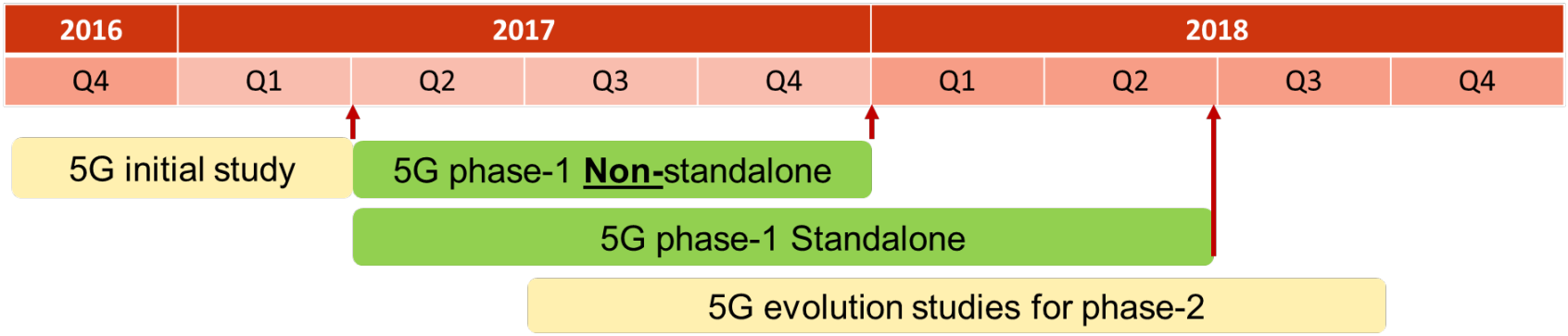
- In September 2017 3GPP RAN plenary re-enforced the timeline commitment for 5G development set out in March 2017.
- Focus for the “early drop” (December/2017)
  - Focus on LTE-anchored LTE-NR Dual Connectivity (DC) – Nonstandalone (NSA) NR
  - Several functions moved beyond December/2017
- Focus for the full Release 15 (June/2018): Standalone (SA)NR with new 5G Core
  - NSA and SA share common 5G NR physical layer specifications for the air interface, and, thus, these aspects were covered in the December 2017 milestone.
  - The main focus for the SA standardization is on the upper layers with full user and control plane capability and on the next-generation core network architecture, including network slicing.

5G Phase 1: Release 15

- Focus is to provide enhanced mobile broadband (eMBB)
- Frequency bands between 450MHz and 52.6 GHz
- LTE-Anchored 5G (NSA), and Standalone (SA) 5G
- Basic URLLC support
- Massive MIMO
- Flexible RAN architecture

Release 15 Timeline

- Release 15 includes two steps and the focus is on the eMBB.
- The first step of phase 1 (Non-standalone) has already been completed in December 2017
- The second step of phase 1 (Standalone) will be completed in June 2018.

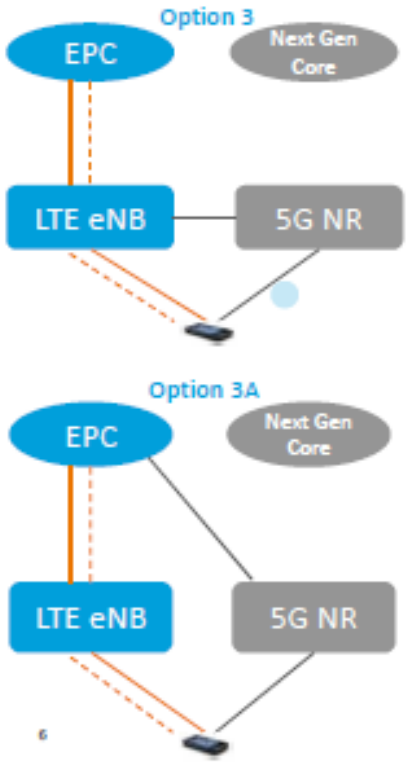


Source 3GPP

Non-standalone vs Standalone

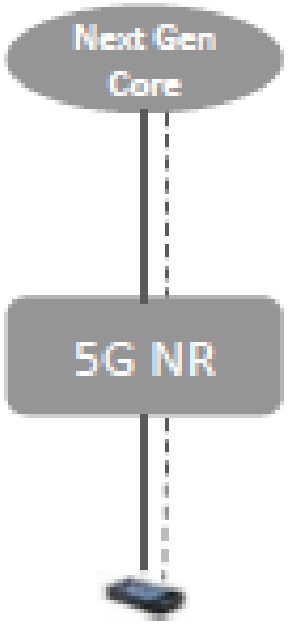
Non-standalone 5G

- Uses LTE anchor, LTE-NR DC and LTE core
- Option 3 - LTE assisted
- Option 3A - EPC connected



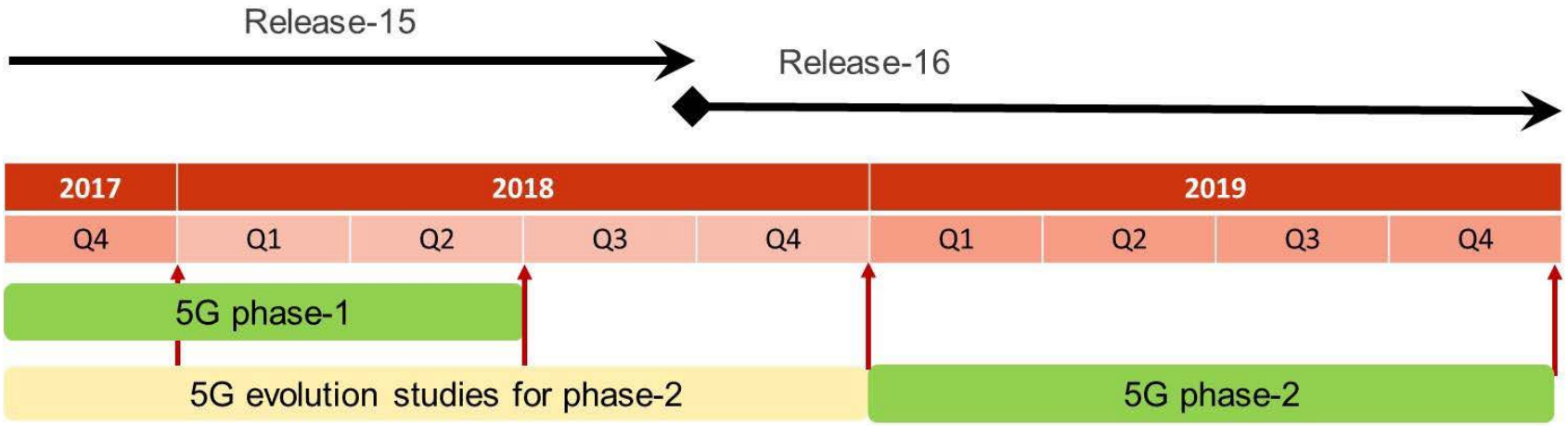
Standalone 5G

- Uses 5G radio and 5G core



5G Phase 2: Release 16

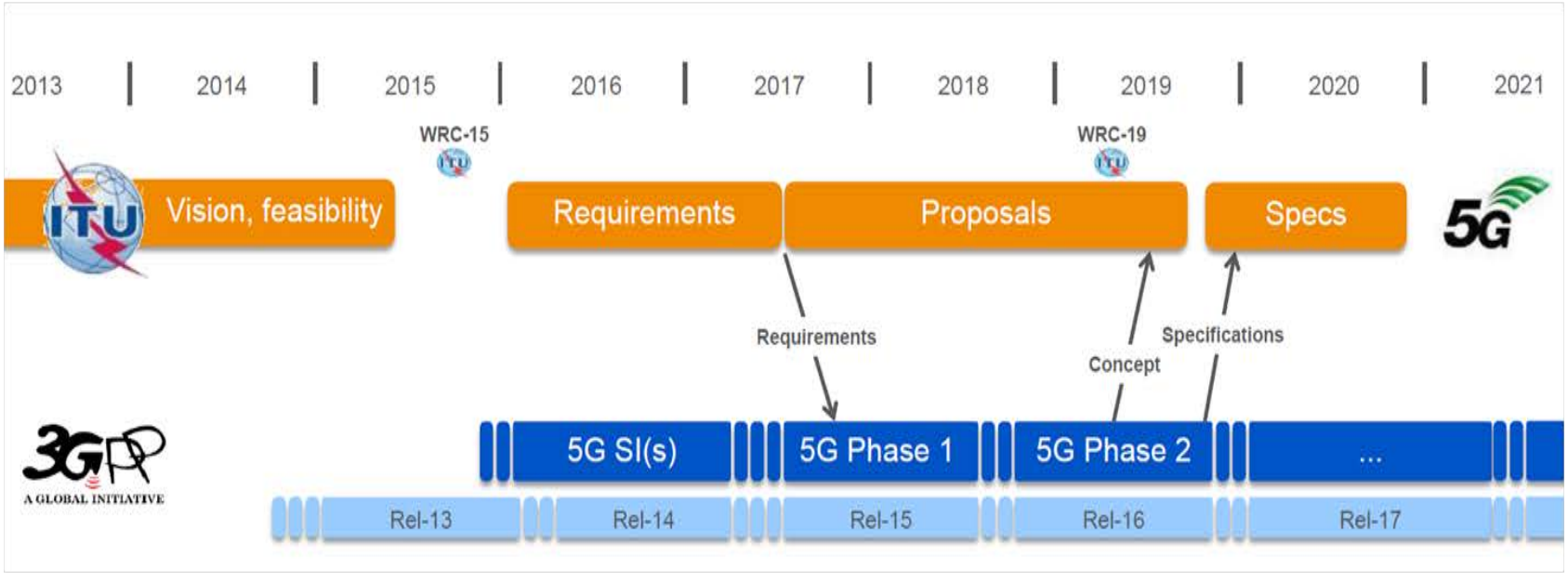
- New features related to URLLC and mMTC
- V2X support – autonomous driving
- Factory automation
- Support for new Unlicensed and Spectrum Sharing paradigms
- Support of higher bands (between 52.6 GHz and 100 GHz)
- Non-Orthogonal Multiple Access (NOMA)



Source 3GPP

ITU and 3GPP Timeline

- Release 16 will be "5G phase 2" and should be completed in December 2019.
- Release 16 will meet the ITU IMT-2020 submission requirements and timeline.



What is 5G NR?

- Operation from low to very high bands 0.45-100 GHz
  - Includes stand-alone operation in unlicensed bands
- Set of different numerologies for optimal operations in different frequency ranges
- Native forward compatibility mechanisms
- Ultra wide bandwidth
  - Up to 200 MHz in <6 GHz, up to 400 MHz in >6 GHz
- New channel coding
  - LDPC for data channel, polar coding for control channel
- Native support for ultra reliable low latency
- Flexible and modular RAN architecture: split front-haul, split C-U plane
- Native end-to-end support for network slicing

Key Characteristics of 5G NR

- Waveform: scalable OFDM, Orthogonal Frequency Division Multiplexing, waveform numerologies supporting low-band, mid-band and high-band spectrum allocations for wideband operation and low latency services.
- Dynamic, slot-based frame structure: enables future-proof and ultra-lean design as well as self-contained subframe structure that allows for data transmissions that efficiently support diverse use cases with requirements that include low latency, high peak-rate, and high reliability.
- Massive MIMO: control and data channel support for Massive MIMO features that improve spectral efficiency and achieve higher data rates.
- Mobile mmWave: control and data channel support for adaptive beamforming and beam-tracking techniques to enable use of high-band mmWave spectrum that deliver extreme data rates and capacity.
- Channel codecs: channel coding schemes based on latest technology in advanced low-density parity-check (LDPC) codes to support large data blocks and extreme peak rates, and Polar codes for reliable control channels.

Scalable OFDM

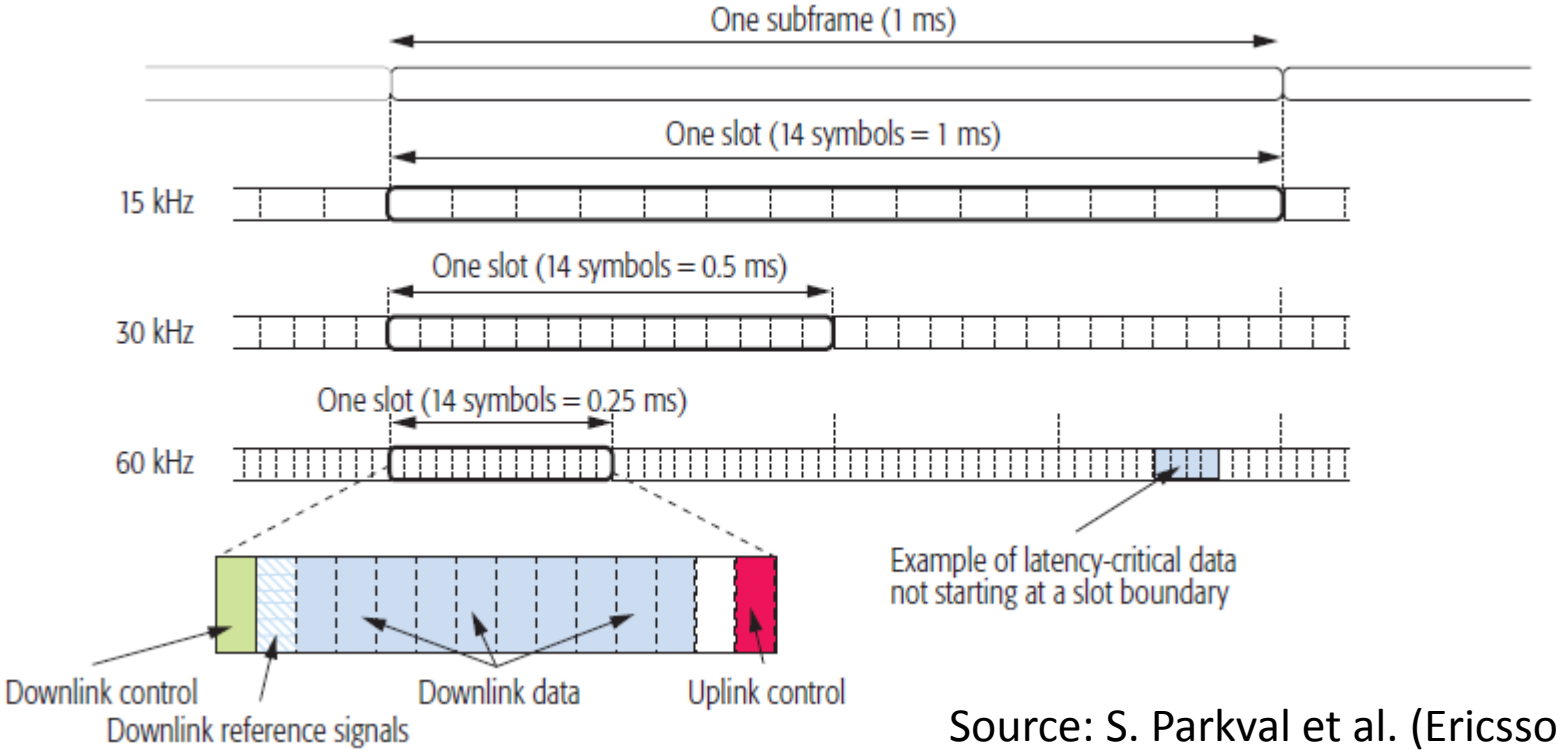
- NR is based on OFDM transmission.
- To support a wide range of deployment scenarios, from large cells with sub 1 GHz carrier frequency up to mmWave deployments with very wide spectrum allocations,
- NR supports a flexible numerology with subcarrier spacings from 15 kHz to 240 kHz with a corresponding change in the duration of guard interval.
- For each frequency band, radio requirements are defined for a subset of the supported numerologies.

Frequency band	Subcarrier spacing	Maximum bandwidth
0.45 GHz–6 GHz	15/30/60 kHz	50/100/200 MHz
24 GHz–52.6 GHz	60/120 kHz	200/400 MHz

Source: S. Parkval et al. (Ericsson)

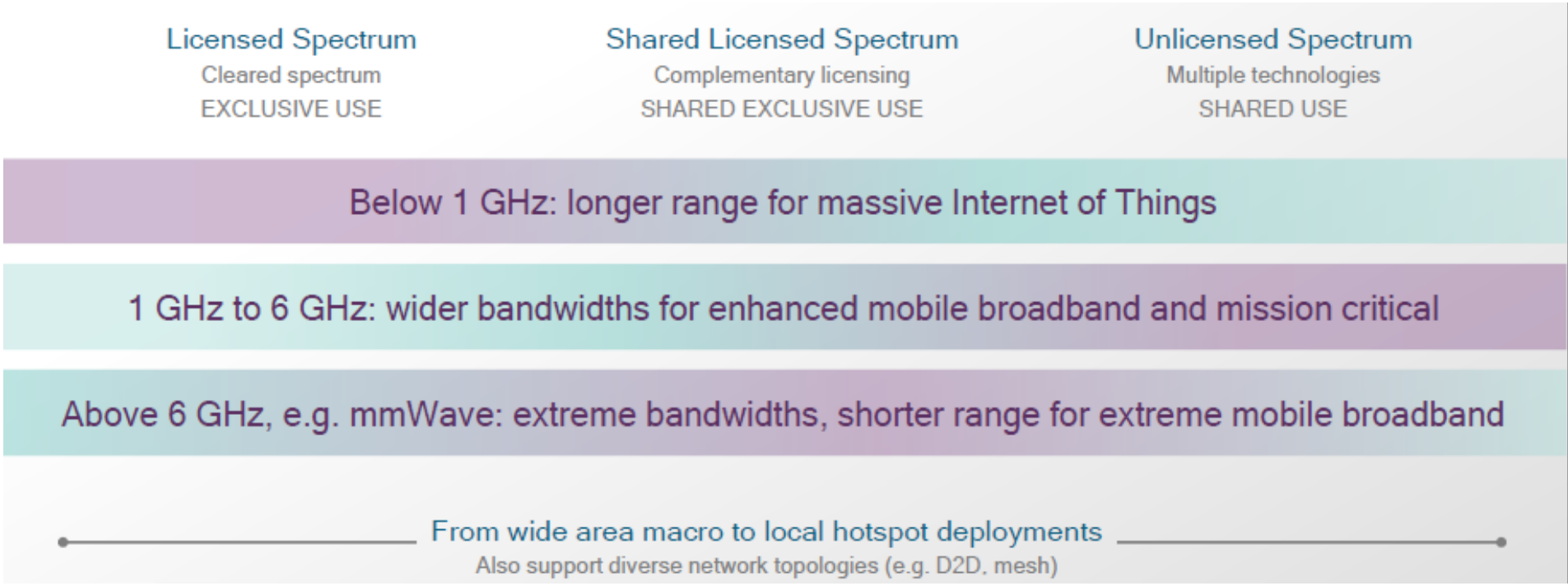
Slot Based Frame Structure

- 10 ms radio frame is divided into ten 1 ms subframes.
- A subframe is divided into slots consisting of 14 OFDM symbols each,
- The duration of each slot in ms depends on the subcarrier spacing.
- Support for low latency by transmission over a fraction of a slot (“minislot”).



Source: S. Parkval et al. (Ericsson)

5G Spectrum Types/Bands



Source: Qualcomm

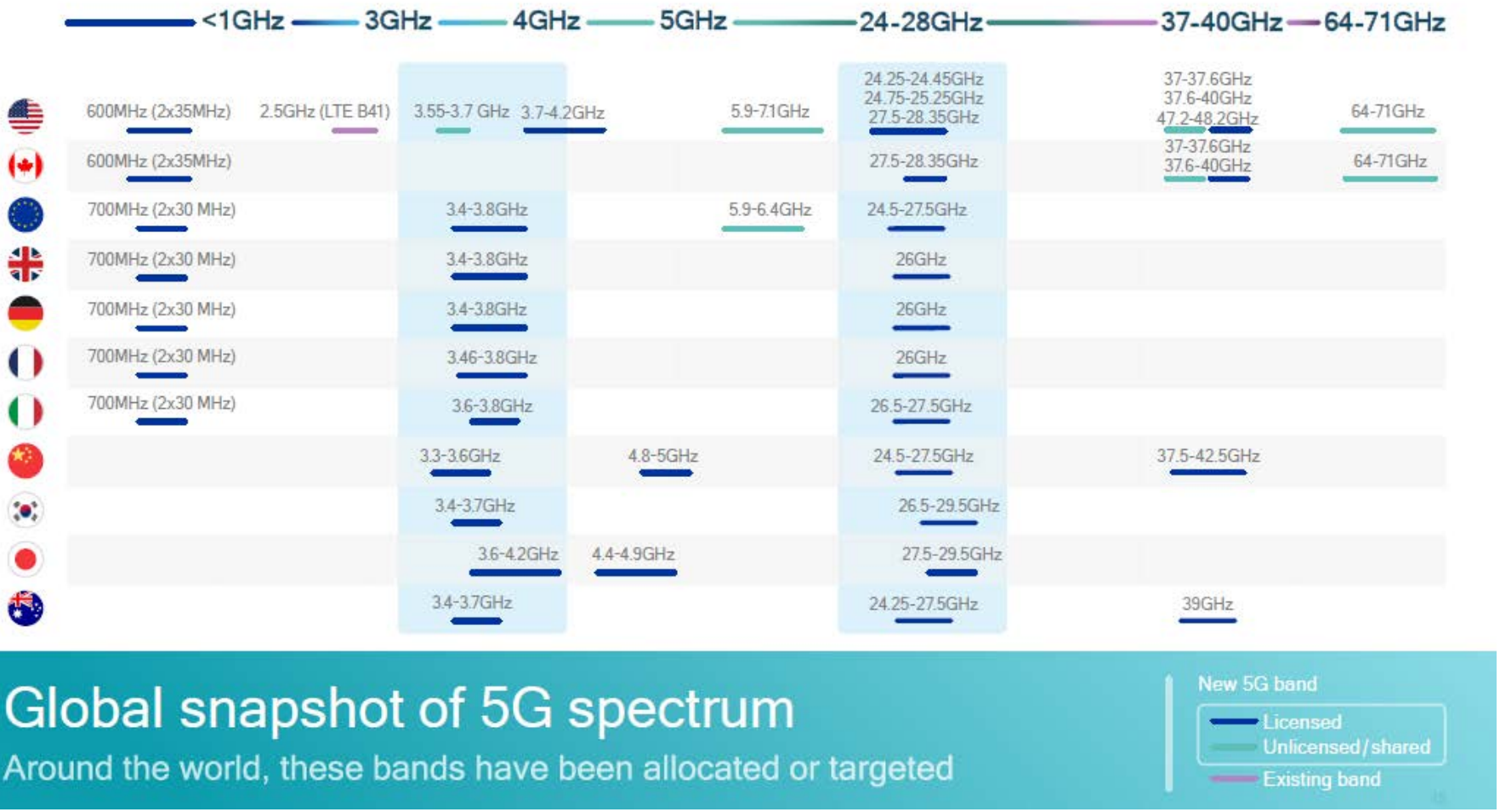
NR Release 15 Frequency Ranges

- 3GPP TS 38.104 section 5.2 provides the list of bands in which NR (New Radio) can operate.
- As per 3GPP release 15, these frequency bands are designated for different frequency ranges (FR)

Frequency Range Designation	Corresponding Frequency Range
FR1	450 MHz – 6000 MHz
FR2	24250 MHz – 52600 MHz

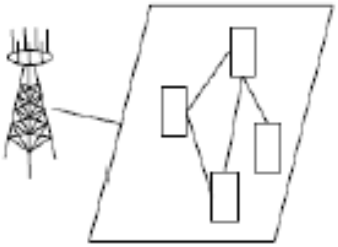
- NR bands can be also classified into three categories
  - Frequency Division Duplex Bands (FDD)
  - Time Division Duplex Bands (TDD)
  - Supplementary Bands (SUL) : Downlink Supplement Bands & Uplink Supplement Bands
- NR has introduced a new notation for band which starts with “n” e.g. Band 20 is noted as n20 where in LTE it was termed as B20.

5G Spectrum in Different Countries



Source: everythingRF

Core Network Architecture Evolution



5G

- Functional entities
- Single Core
- Dedicated Protocols

- Service Based
- Virtualization & Slicing
- Softwarization/Cloudification
- Application Programming Interfaces
- Harmonized Protocols (HTTP, ...)
- Exposure to Third Parties
- Backward & Forward Compatibility

Source: 3GPP (G. Mayer)

ITU-T Standards for 5G Core Network

- ITU Y.3071 “Data Aware Networking (Information Centric Networking) – Requirements and Capabilities” will support ultra-low latency 5G communications by enabling proactive in-network data caching and limiting redundant traffic in core networks.
- ITU Y.3100 “Terms and definitions for IMT-2020 network” provides a foundational set of terminology to be applied universally across 5G-related standardization work.
- ITU Y.3111 “IMT-2020 network management and orchestration framework” establishes a framework and related principles for the design of 5G networks.
- ITU Y.3110 “IMT-2020 network management and orchestration requirements” describes the capabilities required to support emerging 5G services and applications.
- ITU Y.3101 “Requirements of the IMT-2020 network” describes the features of 5G networks necessary to ensure efficient 5G deployment and high network flexibility.
- ITU Y.3150 “High-level technical characteristics of network softwarization for IMT-2020” describes the value of slicing in both horizontal and vertical, application-specific environments.
- ITU Y.313**0** “Requirements of IMT-2020 fixed-mobile convergence” calls for unified user identity, unified charging, service continuity, guaranteed support for high quality of service, control plane convergence and smart management of user data.

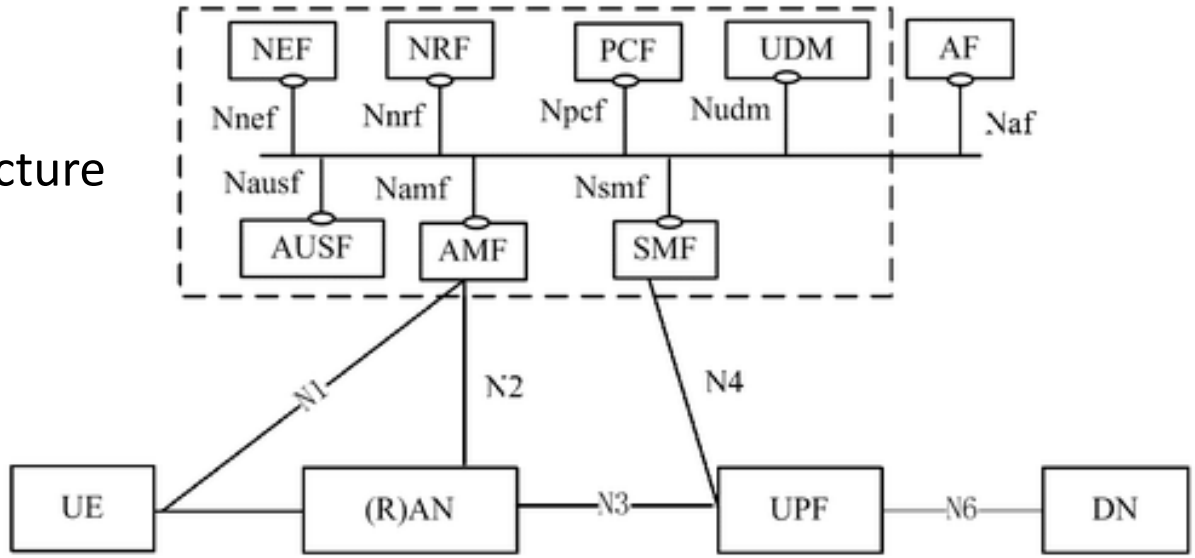
Requirements of the IMT-2020 network (ITU Y.3101)

- Network flexibility and programmability
- Fixed-mobile convergence
- Enhance mobility management
- Deployment and migration
- Network capability exposure
- Authentication
- Security and personal data protection
- Efficient signaling
- QoS Control
- Network management
- Charging
- Interworking

3GPP 5G Core Network

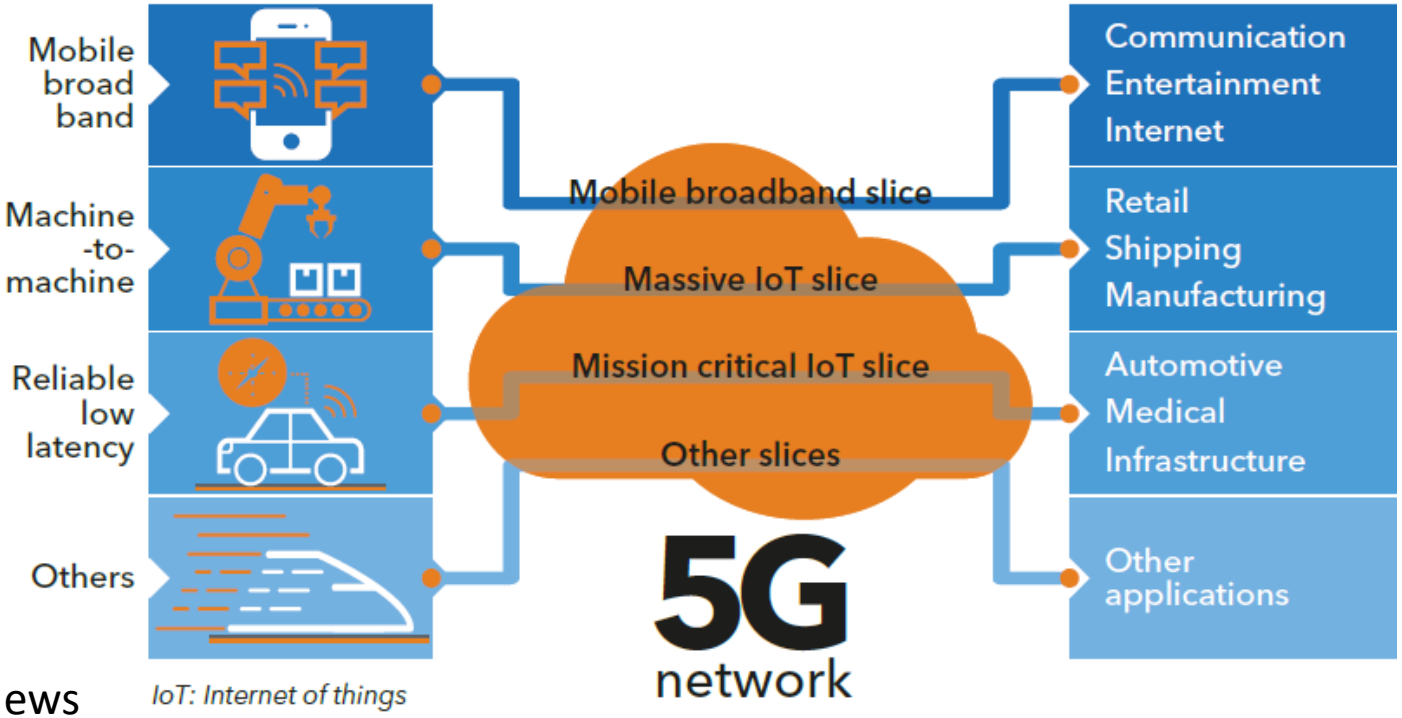
- Reorganization of functions among terminals, the Radio Access Network (RAN) and the core network.
- User Plane and Control Plane separation.
- Introduction of service based arcitecture.
- Support of Network Virtualization.
- Introduction of Network Slicing and simultaneous connection of multiple gateways.

Service based architecture
Source: 3GPP TR 23.501



Network Slicing

- Network slicing allows a network operator to provide dedicated virtual networks with functionality specific to the service or customer over a common network infrastructure.
- It will be able to support the numerous and varied services envisaged in 5G.



Source: ITUNews

ISRM Technical Committee for Electronic Communications (TC2)

- The Standardization Institute of Republic of Macedonia (ISRM) was founded in 2003.
- ISRM Committee for electronic communications (TC2) was founded in 2008.
- ISRM TC2 is a mirror of ETSI and covers the same areas as ETSI, i.e. its Technical Committees, Industrial Specification Groups, Special Committees and Partnership Projects, such as 3GPP.
- In December 2006 ETSI recognized ISRM as the National Standardization Organization in the area of telecommunications.
- ISRM has signed with ETSI a Memorandum of cooperation with ETSI for realizing the standardization procedures (public consultation, adoption, withdrawal) and Sales Agreement.
- ISRM TC2 has adopted over 1000 ETSI EN standards as national standards and has withdrawn over 200 old and conflicting standards and standardization documents (former Yugoslav standards and old versions of European standards adopted as Macedonian standards).

Activities of ISRM TC2

- In ETSI numerous standardization activities are currently taking place, and significant activities are going on in ISGs and Partnership Projects 3GPP and oneM2M.
- ISRM TC2 as a mirror of ETSI has huge importance for the standardization of electronic communications in Republic of Macedonia.
- ISRM TC2 is continuing with the adoption of ETSI EN standards as national standards.
- ISRM TC2 is taking part in ETSI activities through announcing public enquiry, establishing national position and voting for EN standards.
- Depending on the interests of the members and other parties, future activities could include producing entirely Macedonian standards.
- One of the goals is increasing the TC2 membership, especially from the industry side (and, in particular, from the vendor side).