Etienne Chaponniere
Sr. Director, Technical Standards

Introduction to 5G

QUALCOMM®

DASH-IF
August 20th 2015

Mobile has made a leap every ~10 years

1G

Analog voice

AMPS, NMT, TACS

1980s

2G

Digital voice

D-AMPS, GSM, IS-95 (CDMA)

1990s

3G

Mobile broadband

WCDMA/HSPA+, CDMA2000/EV-DO

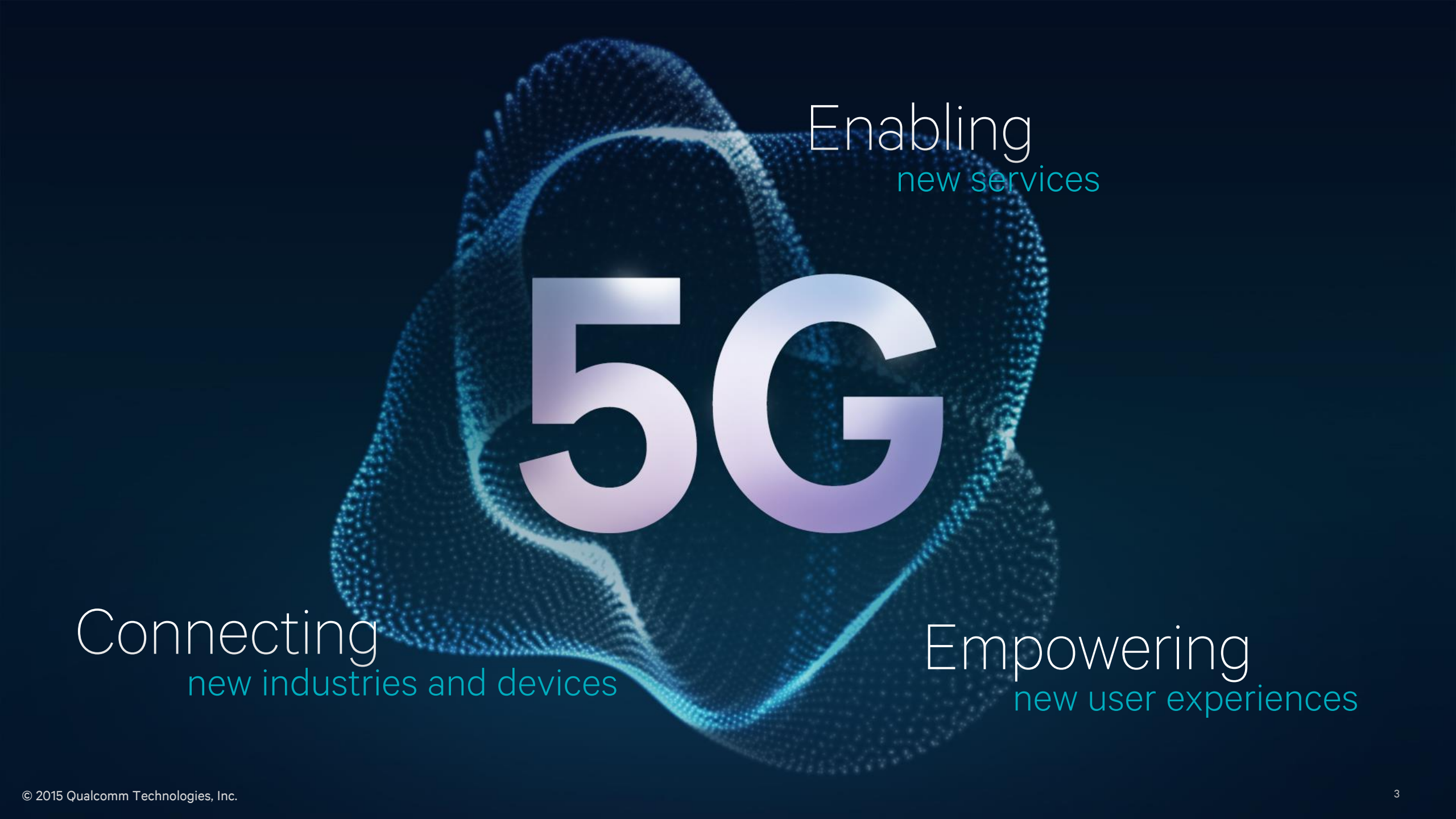
2000s

4G

Faster and better MBB

LTE, LTE Advanced

2010s



Potpourri of Organizations Working on 5G

Research Organizations	Promotion Groups	Standards Organizations
• China Academy of Information and Communications Technology • China National High-Tech R&D (863) Program • Cost – European Cooperation in Science and Technology • IEEE Communications Society • IEEE Vehicular Technology Society • The 5G Infrastructure Public Private Partnership (5G-PPP) • The METIS 2020 Project • Wireless World Research Forum	• 4G Americas • GSM Association (GSMA) • Next Generation Mobile Networks (NGMN) • 5G Forum • FuTURE Communication Forum • IMT-2020 (5G) Promotion Group • The Fifth Generation Mobile Communication Promotion Forum (5GMF)	• 3GPP • ARIB • ATIS • CCSA • ETSI • ITU • TIA • TSDSI • TTA • TTC

Mobile has made a leap every ~10 years

IMT - International Mobile Telecommunication

- IMT-2000
  - CDMA Direct Spread – UMTS/WCDMA/HSDPA FDD (3GPP)
    LTE Release 8/E-UTRA
  - CDMA Multi-Carrier – cdma2000 (3GPP2)
  - CDMA TDD – UMTS TDD & TD-SCDMA (3GPP)
  - TDMA Single-Carrier – UWC-136 (TIA)
  - FDMA/TDMA – DECT (ETSI)
  - OFDMA TDD WMAN – 802.16e/WiMAX (IEEE)
- IMT-Advanced
  - LTE Release 10 (3GPP)
  - WiMAX 802.16m (IEEE)

3G

Mobile broadband

WCDMA/HSPA+,
CDMA2000/EV-DO

2000s

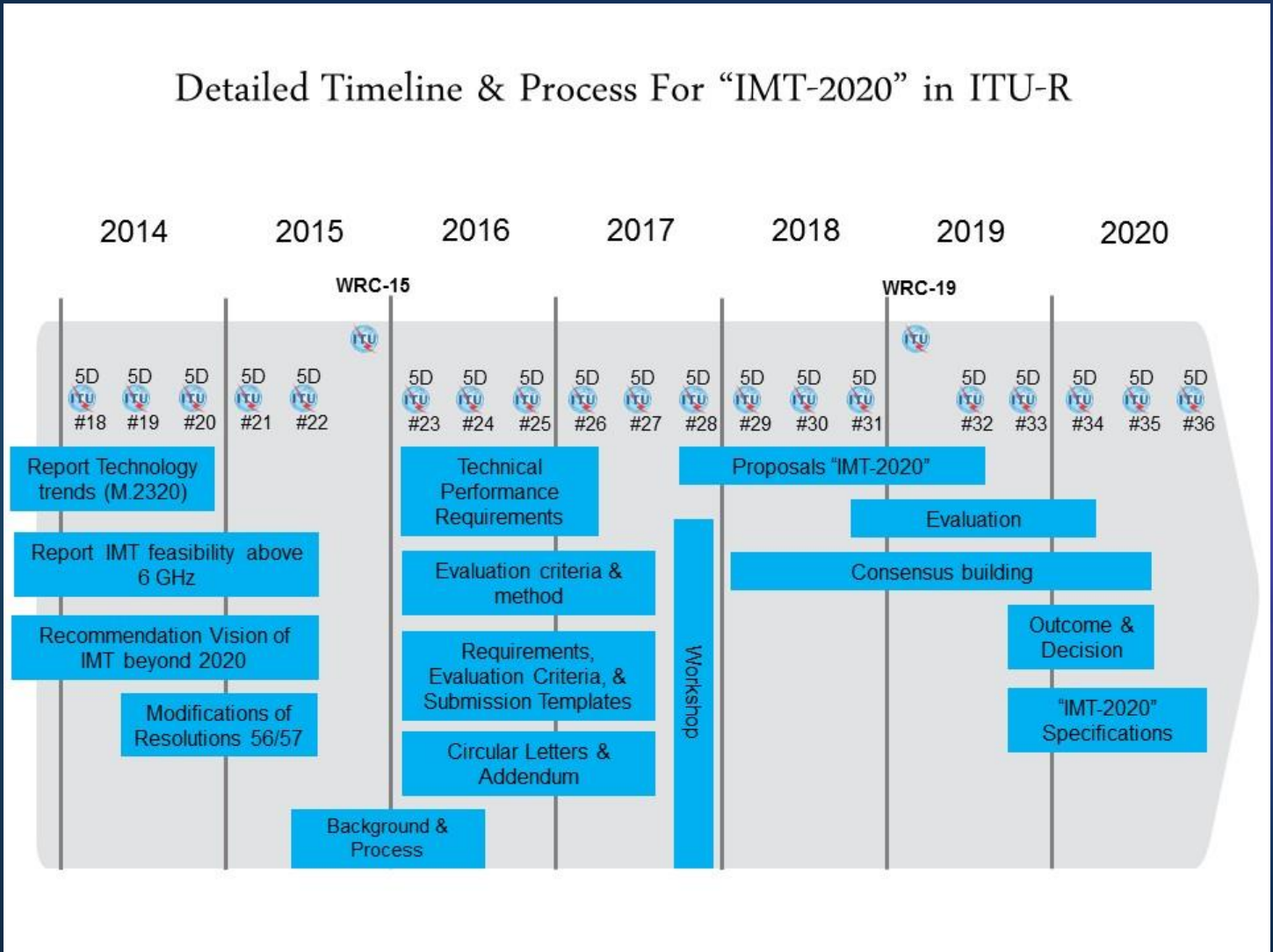
4G

Faster and
better MBB

LTE, WiMAX
LTE Advanced, WiMAX

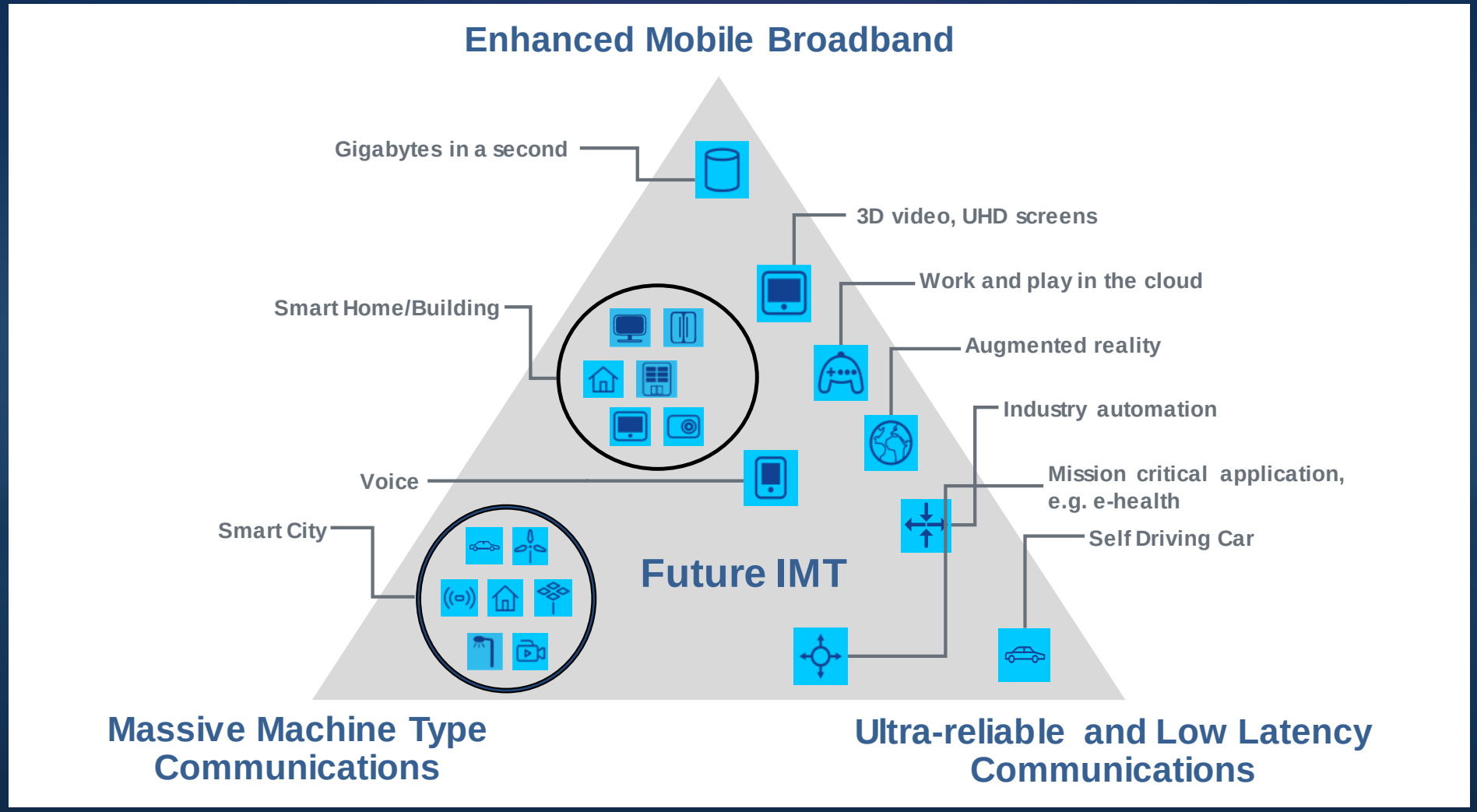
2010s

IMT-2020 – The ITU Vision

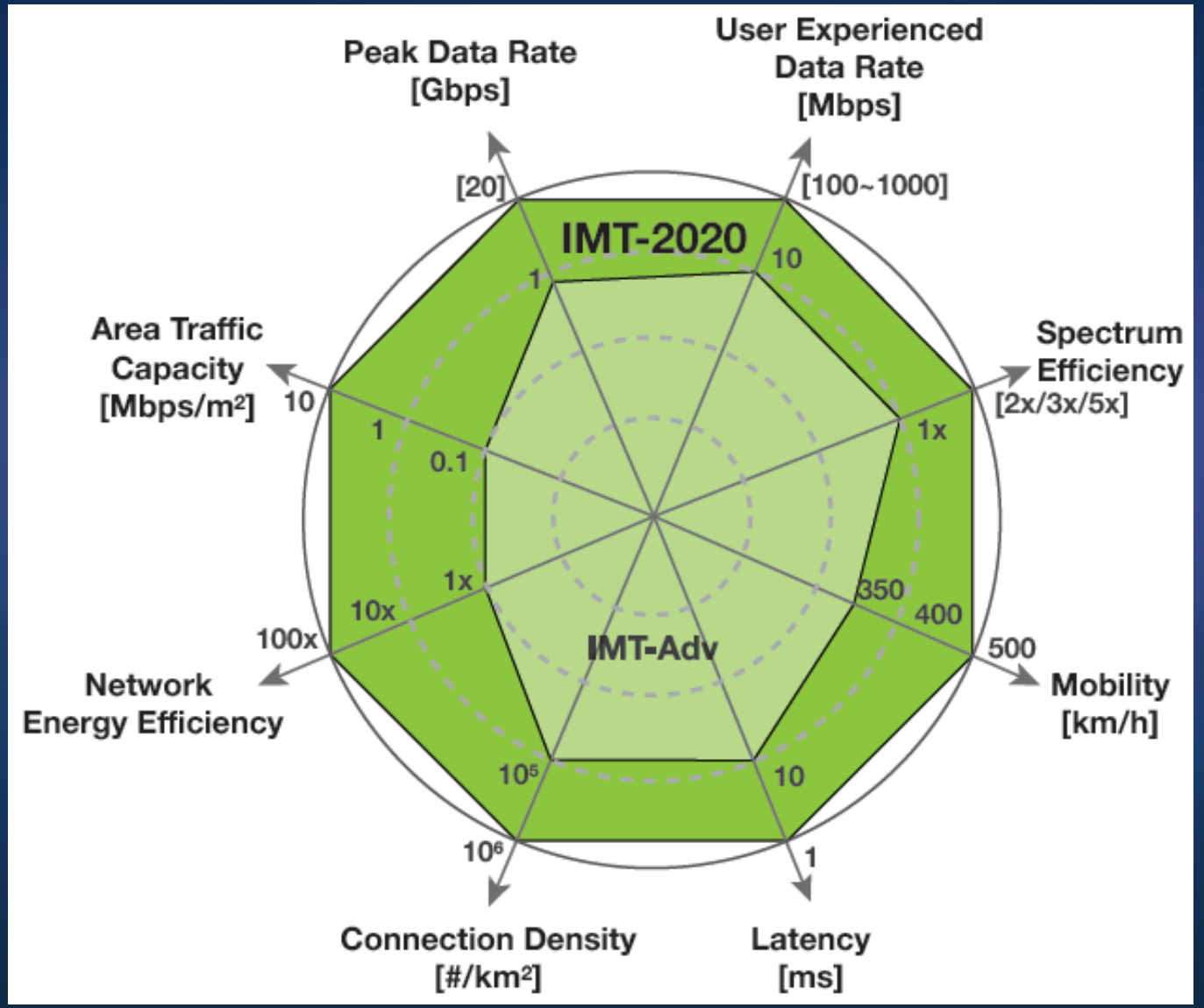


- M.2290 - M.[IMT.2020.ESTIMATE] – *"Future spectrum requirements estimate for terrestrial IMT"* – December 2013
- M.2320 - M.[IMT.FUTURE TECHNOLOGY TRENDS] - *Future technology trends of terrestrial IMT systems* – October 2014
- M.[IMT.ABOVE 6 GHz] - *The technical feasibility of IMT in the bands above 6 GHz* –WP 5D targets finalization in June 2015
- M.[IMT.Vision] – *Framework and overall objectives of the future development of IMT for 2020 and beyond* –WP 5D targets finalization in June 2015
- M.[IMT.BEYOND2020.TRAFFIC] – *IMT Traffic estimates beyond the year 2020* –WP 5D targets finalization in June 2015
- M.[IMT.ARCH] - *Architecture and Topology of IMT Networks* –WP 5D targets finalization in June 2015

The WP 5D View in M.[IMT.Vision]

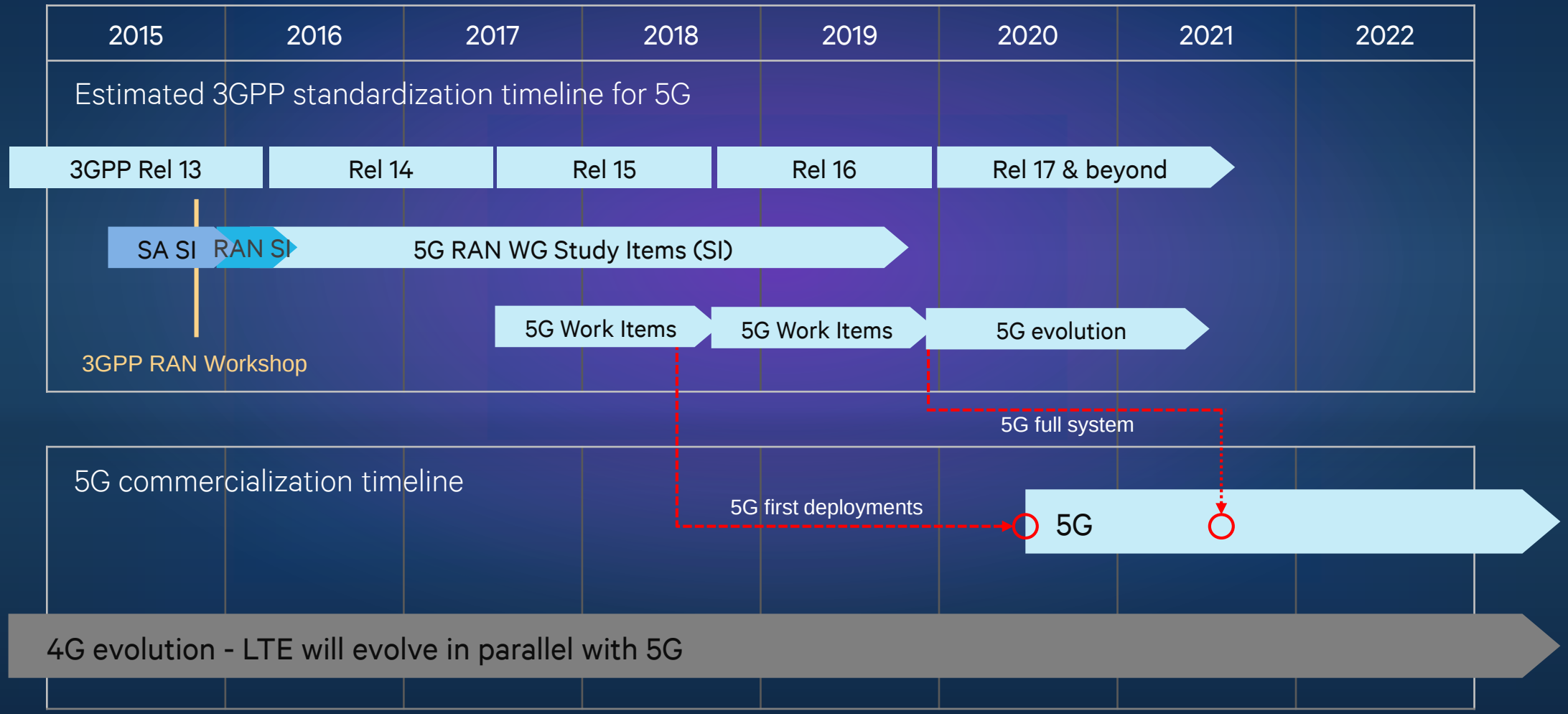


The WP 5D View in M.[IMT.Vision]



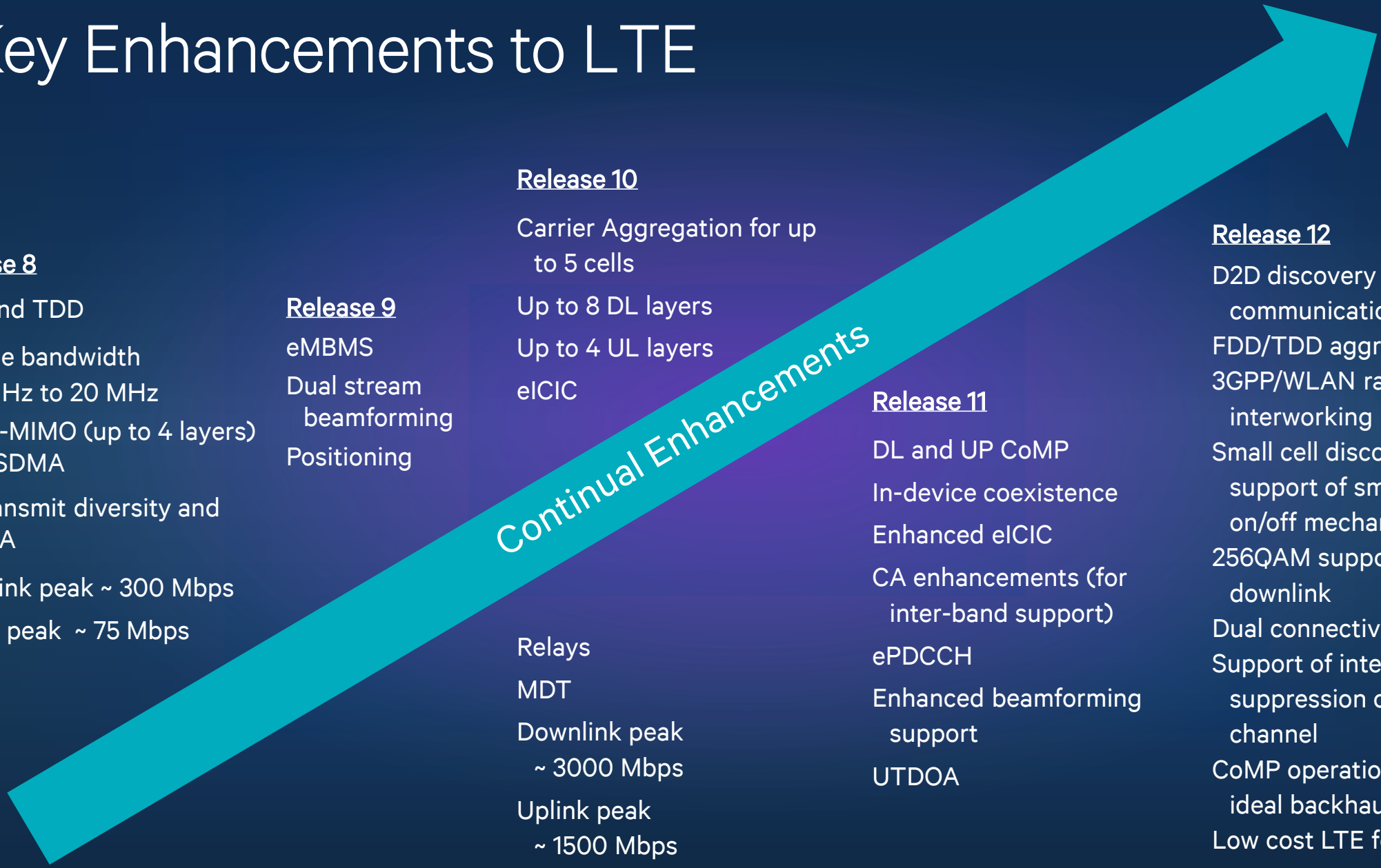
Current 3GPP timeline delivers 5G specification by 2020*

5G timeline – our view



* For information on 3GPP's 5G timeline, see: http://www.3gpp.org/news-events/3gpp-news/1674-timeline_5g

Key Enhancements to LTE



Release 8

FDD and TDD

Flexible bandwidth 1.4 MHz to 20 MHz

DL SU-MIMO (up to 4 layers) and SDMA

UL Transmit diversity and SDMA

Downlink peak ~ 300 Mbps

Uplink peak ~ 75 Mbps

Release 9

eMBMS

Dual stream beamforming

Positioning

Release 10

Carrier Aggregation for up to 5 cells

Up to 8 DL layers

Up to 4 UL layers

eICIC

Relays

MDT

Downlink peak ~ 3000 Mbps

Uplink peak ~ 1500 Mbps

Release 11

DL and UP CoMP

In-device coexistence

Enhanced eICIC

CA enhancements (for inter-band support)

ePDCCH

Enhanced beamforming support

UTDOA

Release 12

D2D discovery and communication (ProSe)

FDD/TDD aggregation

3GPP/WLAN radio-level interworking

Small cell discovery and support of small cell on/off mechanisms

256QAM support in downlink

Dual connectivity

Support of interference suppression on the data channel

CoMP operation w/ non-ideal backhaul

Low cost LTE for MTC

Release 13

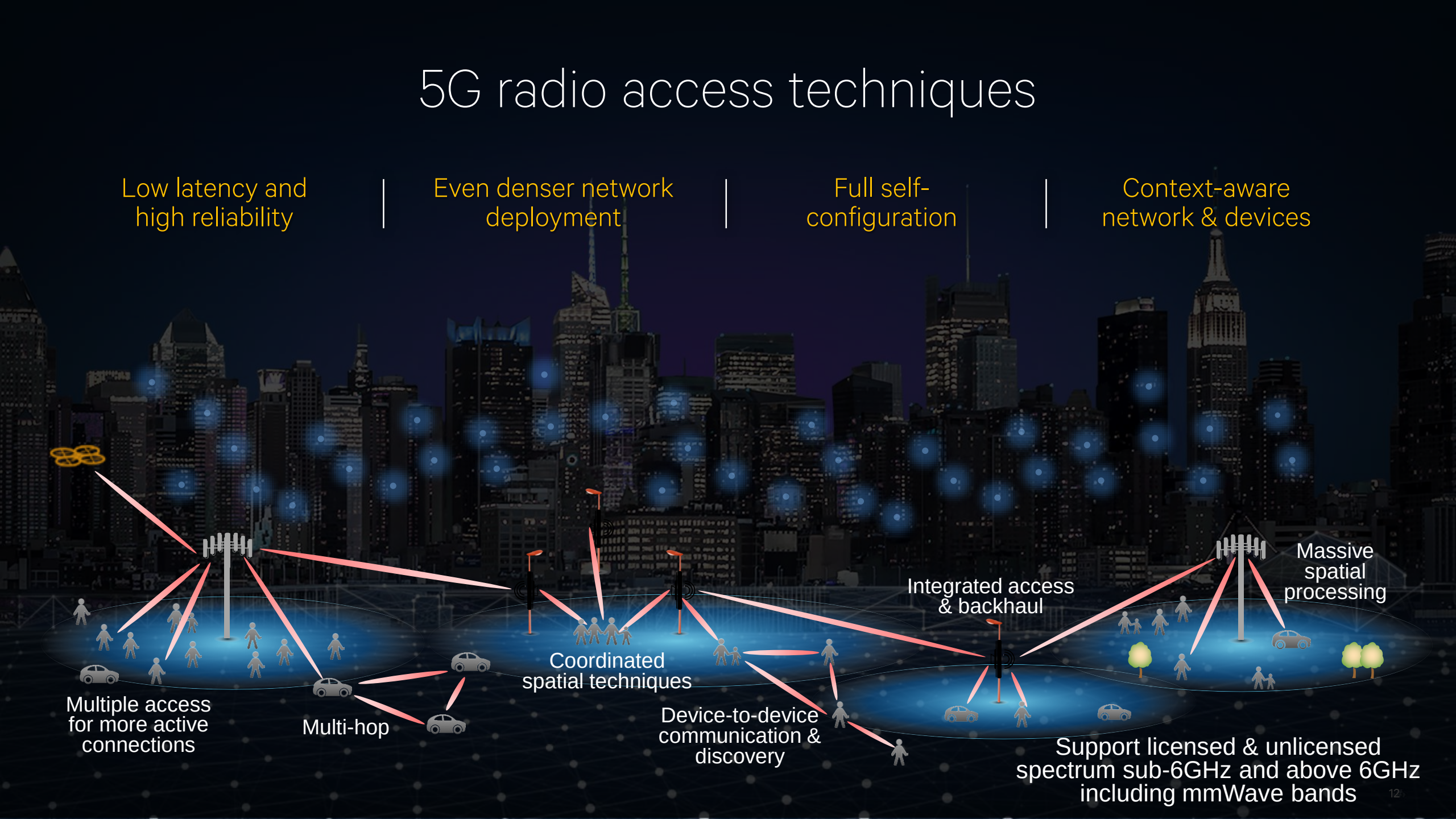
LTE Release 13

- LAA (License Assisted Access)
- LTE-Wifi Aggregation
- Further enhancements for MTC (low cost / range / power)
- Enhancements for D2D and DC operation
- 3D/FD MIMO
- Indoor positioning
- Single-cell Multi-Point
- Latency reduction*
- Non-orthogonal Multiple Access*

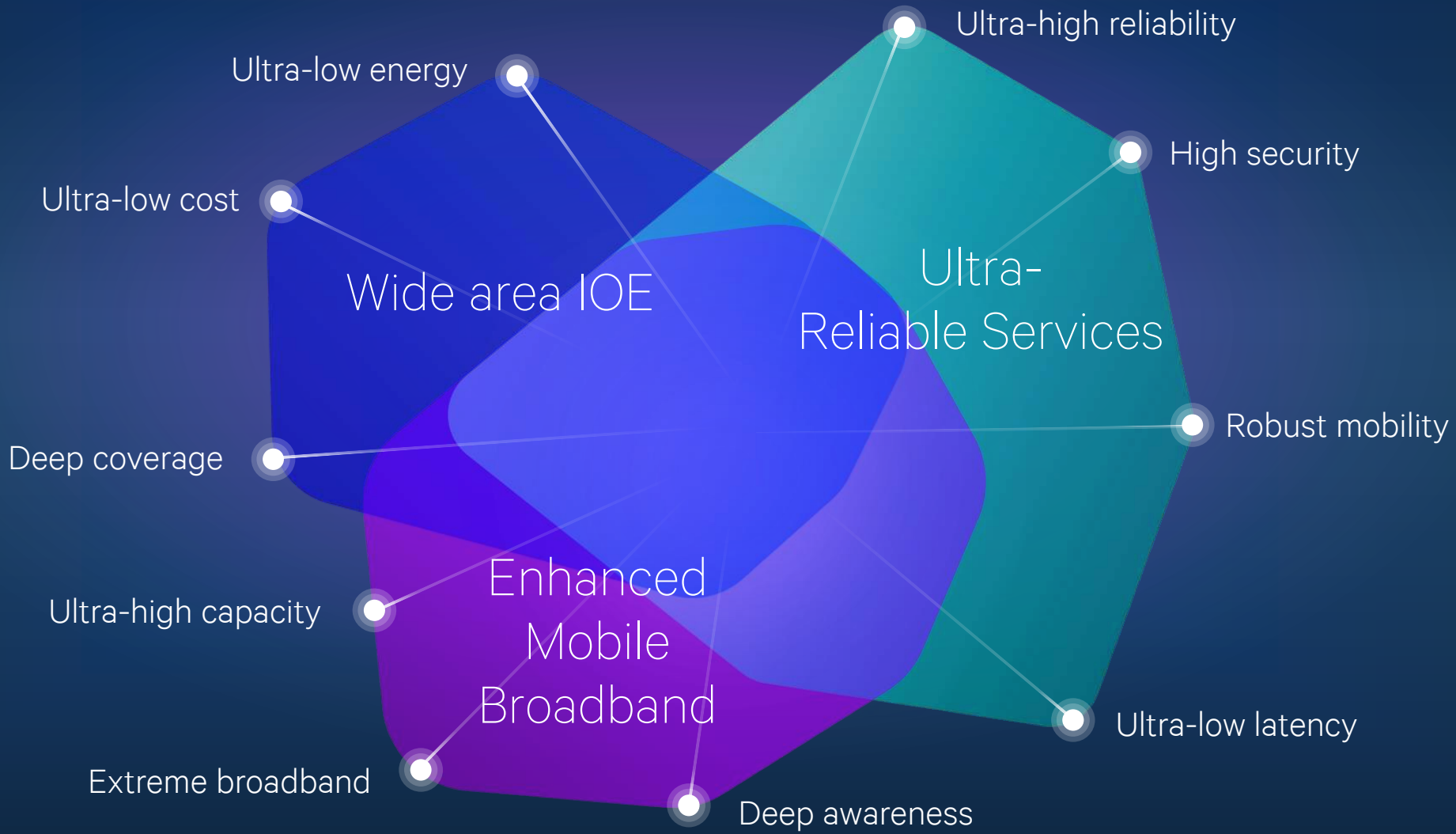
* *Studies targeting normative work in Rel-14*

5G radio access techniques

Low latency and high reliability | Even denser network deployment | Full self-configuration | Context-aware network & devices



Extreme variation of requirements



5G Unified Air Interface (UAI)

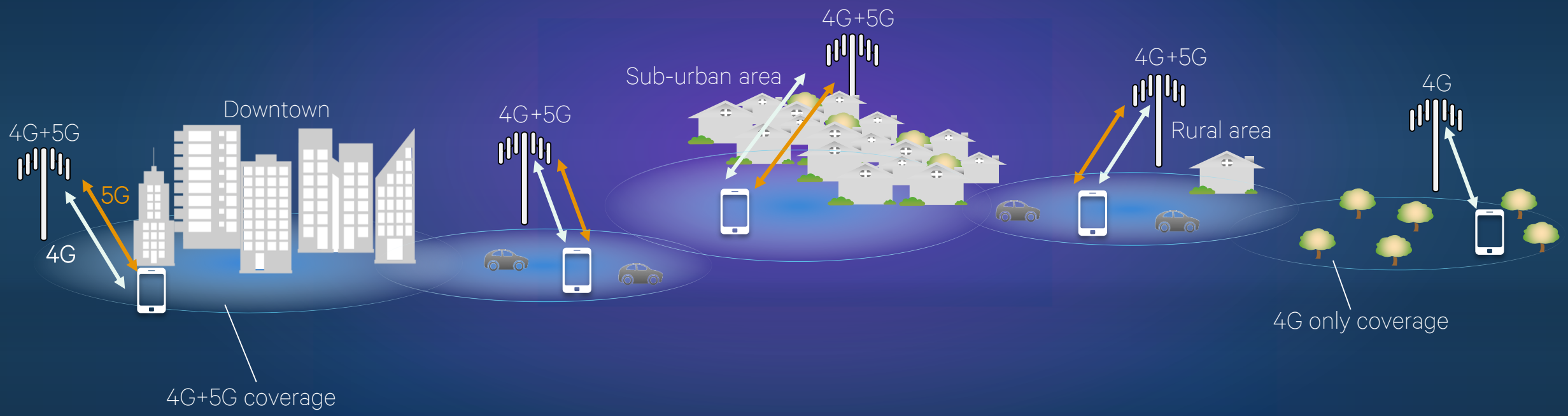
Multiple techniques under a common framework to support diverse requirements & spectrum types

Extreme Range of Application Requirements

Diverse Spectrum Types

Phased 5G rollout leveraging 4G coverage

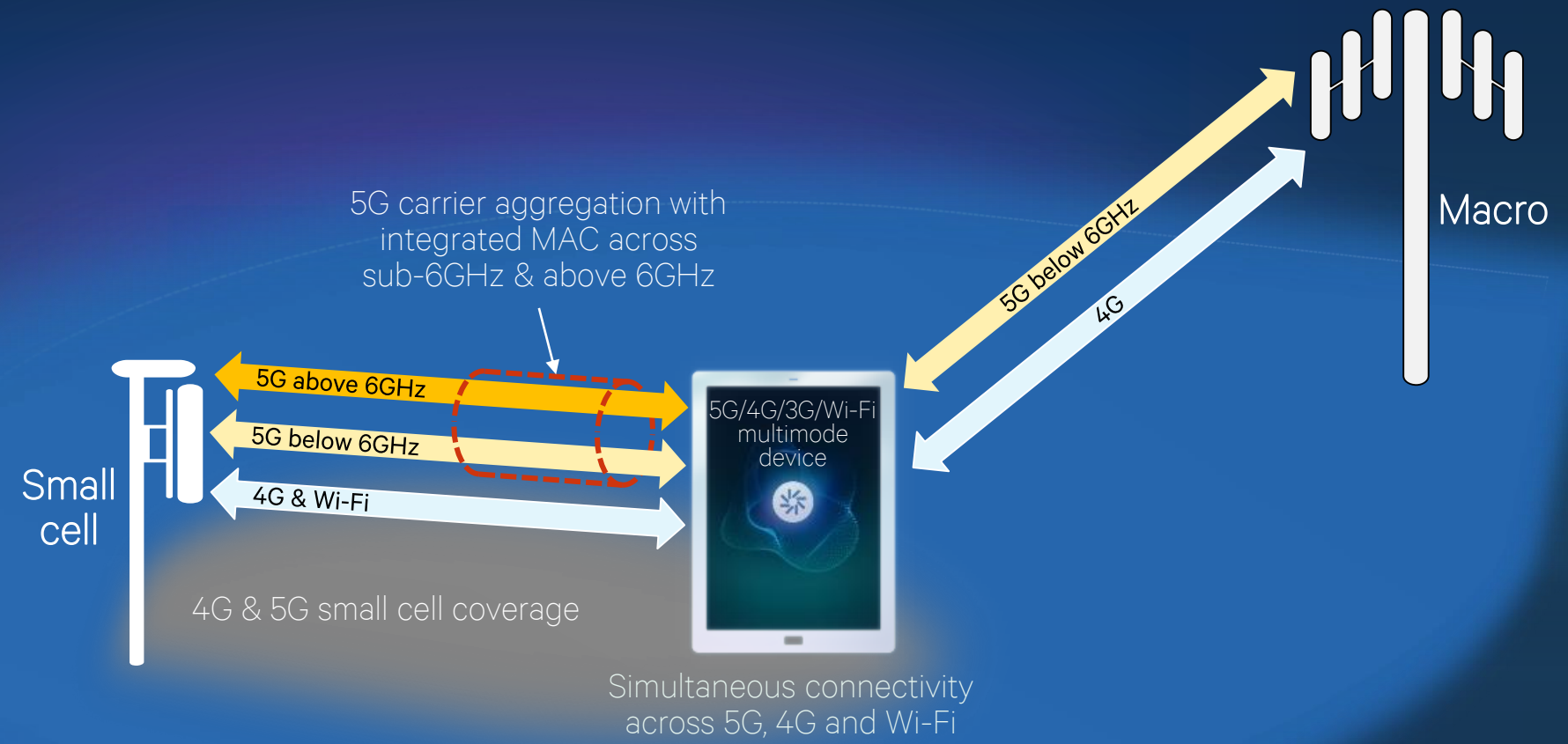
4G+5G multi-connectivity ensures coverage and seamless mobility



Phased 5G rollout

Multi connectivity across bands & technologies

Leverage 4G investments and enable phased 5G rollout



5G deployment scenarios:

- Deploy below 6GHz
- Deploy above & below 6GHz when available

mmWave enables 5G Extreme Mobile Broadband

Opportunities

- Availability of large bandwidth from 100s of MHz up to 9 GHz
- Extreme data-rates (e.g. up 10 Gbps)
- Dense spatial reuse can enable extreme network capacity
- Beamforming to overcome poorer propagation
- Flexible deployment with integrated backhaul (200m – 500m) and access (100m- 150m)

Challenges

- Higher path-loss at mmWave frequencies, susceptibility to blockage
- Robust beam search & tracking
- System design with directional transmissions
- Device cost and RF challenges at mmW

Solutions

- Tight integration with 5Gsub6 increases robustness
- Smart beam search & tracking algorithms
- Antenna management & reconstructive beam forming algorithms
- Coordinated scheduling for proximal user interference management
- Phase noise mitigation in RF components for cheaper devices

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IEEE

6-10 DECEMBER 2015
SAN DIEGO, CA, USA
www.ieee-globecom.org/2015

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