5G Standards and Progress

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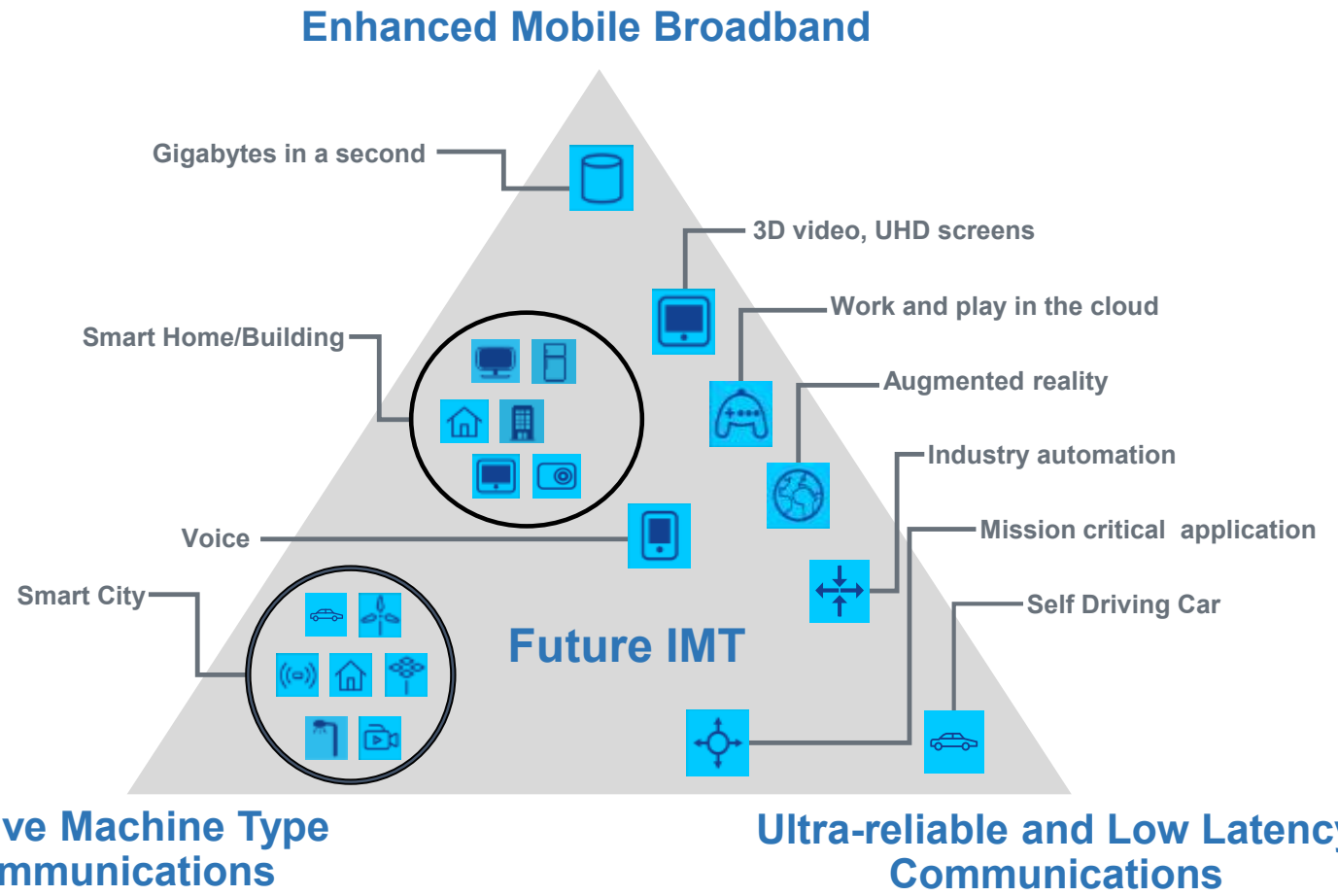
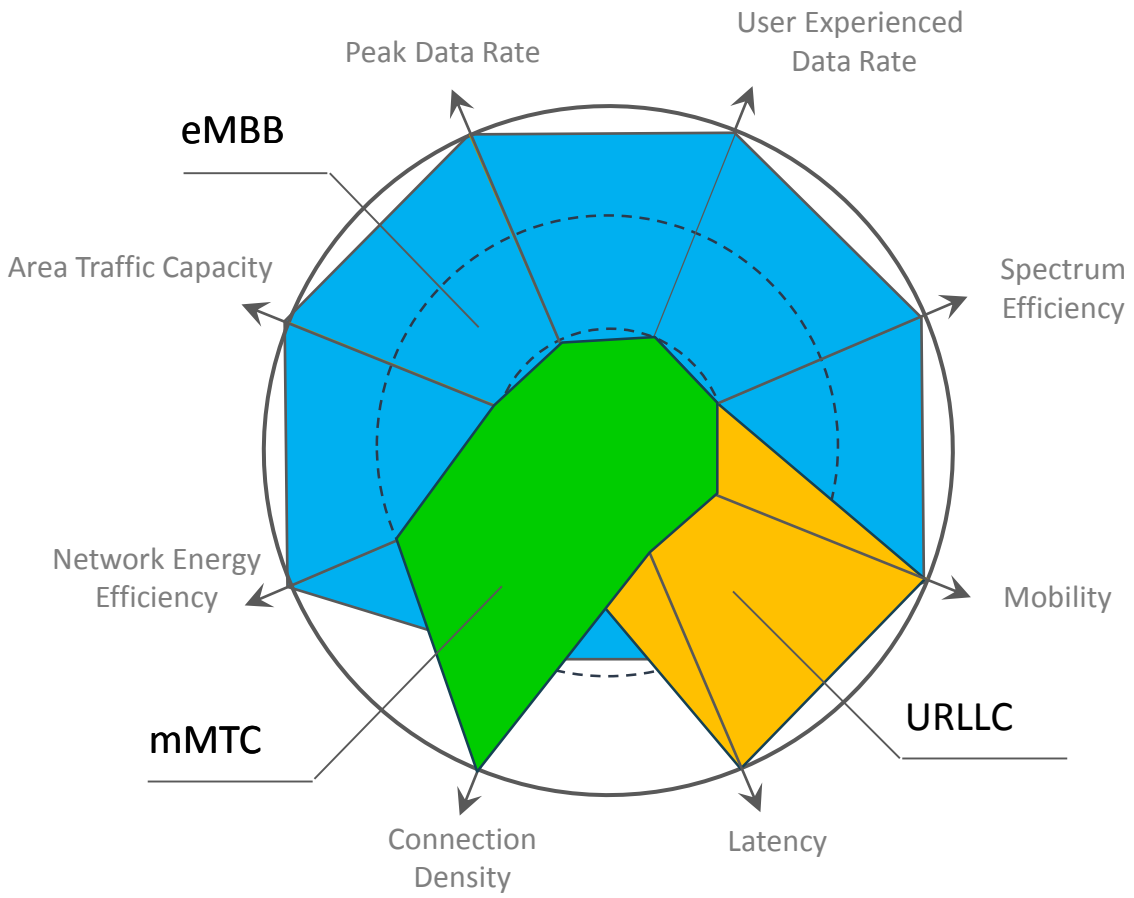
Agenda

- Quick view of ITU on 5G
- Introduction of 3GPP
- 5G Timeline
- 5G scenarios and KPIs

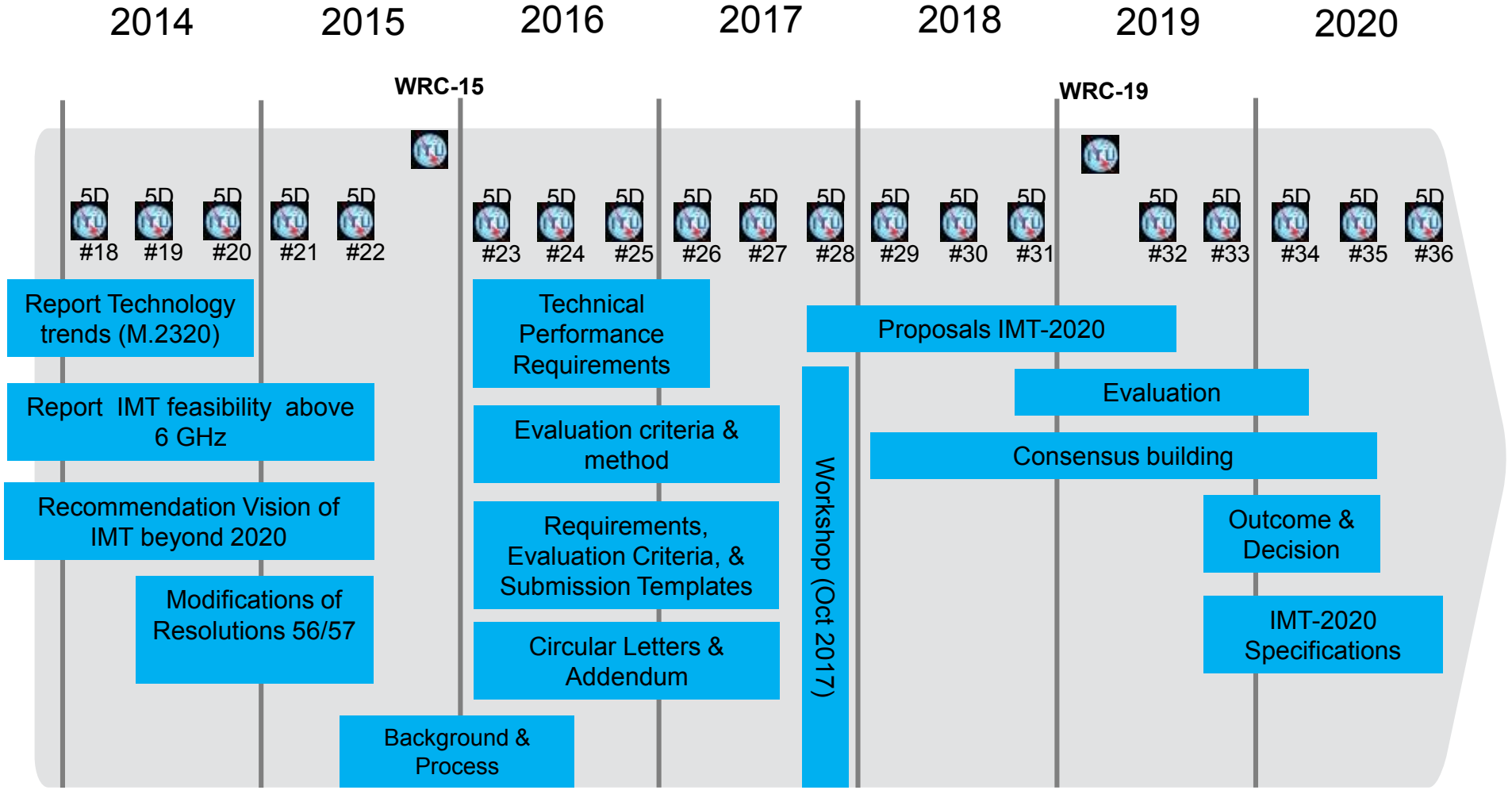
IMT-2020 Usage Scenarios



IMT-2020 Key Capabilities



ITU Timeline for IMT-2020



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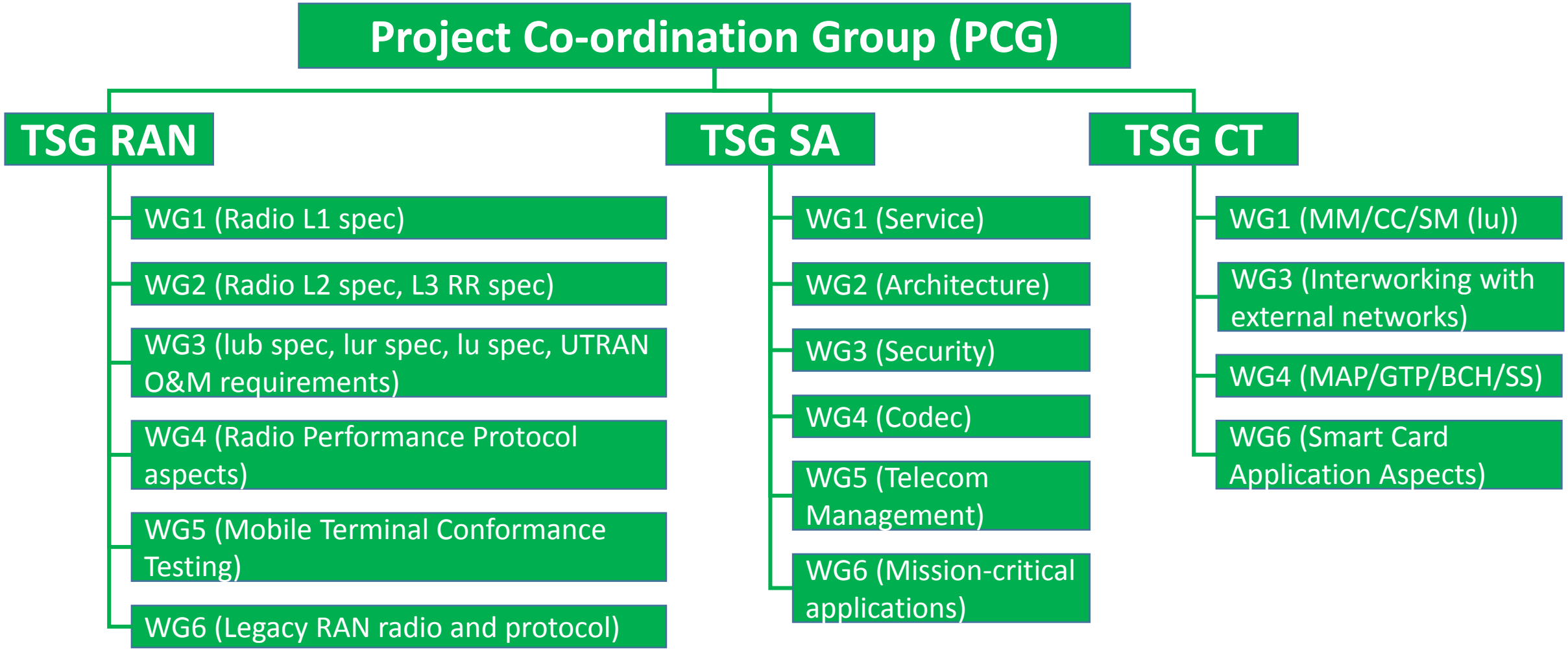
3GPP

- 3rd Generation Partnership Project
  - 7 partners

- Global cellular standards producer
  - W-CDMA, TD-SCDMA, HSPA, LTE, LTE-Advanced, LTE-Advanced Pro. 5G-NR
- Technical standards for the whole system
  - Radio, Core, O&M
  - Infrasturcture, Terminal

3GPP Structure



Project Coordination Group (PCG)

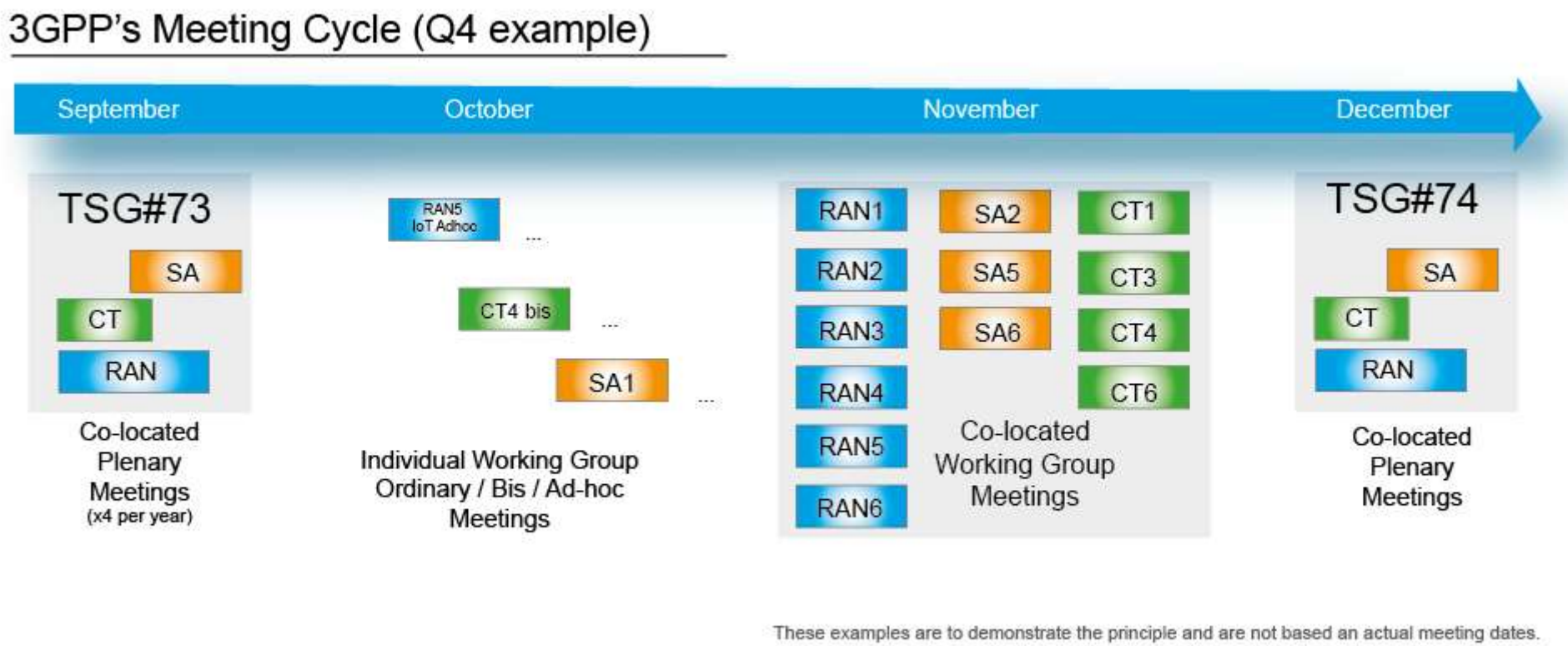
- The highest decision making body in 3GPP
- Ratify election results and the resources committed to 3GPP
- Carry out the final adoption of 3GPP TSG work items
- meets formally every six months

- Members are
  - Delegates from 7 partners
  - Chairman and vice chairmen of TSG

TSG and WGs

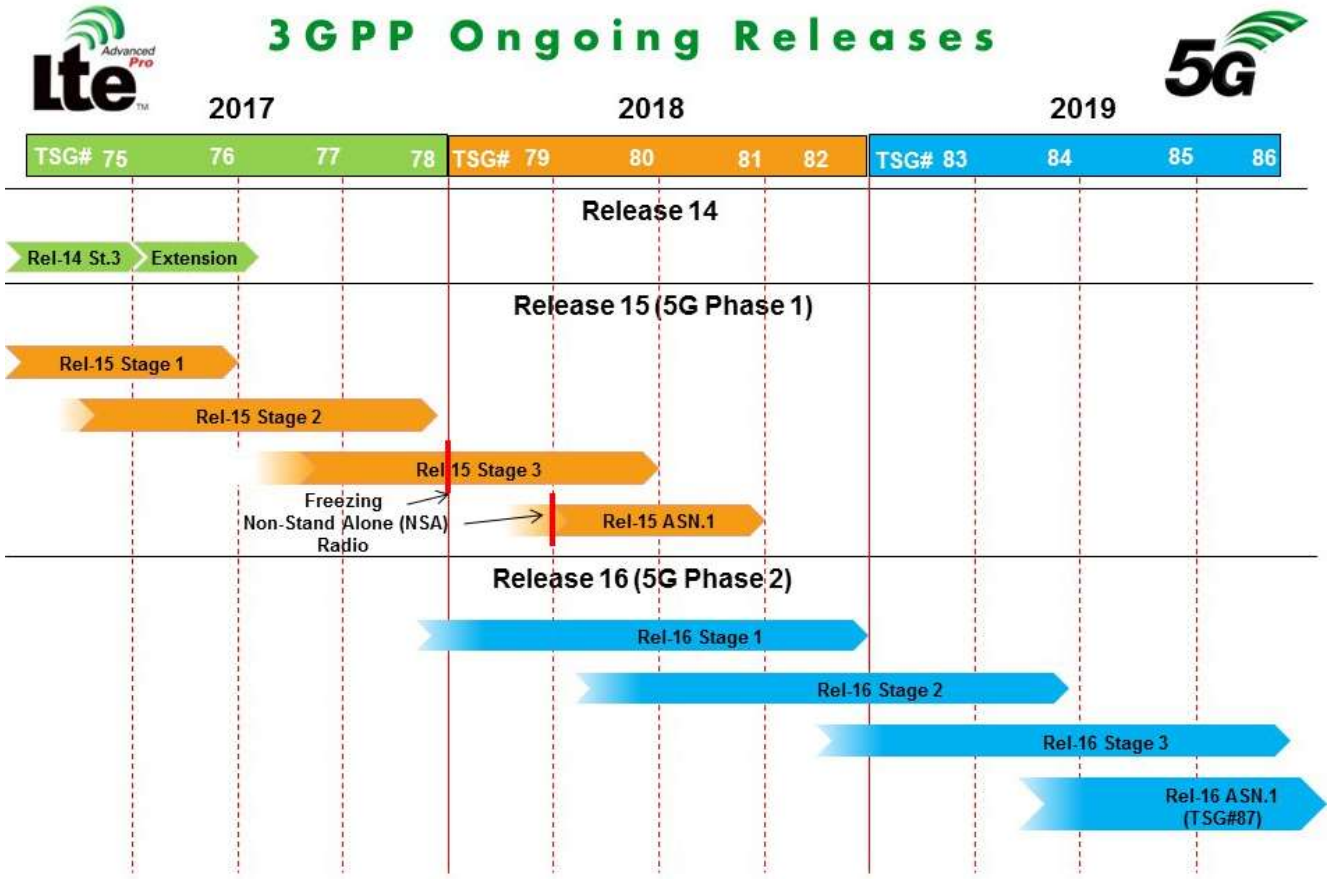
- The TSGs are the main bodies to prepare, approve and maintain the 3GPP Technical Specifications and Technical Reports
  - Creation of TSG Working Groups and approval of their terms of reference
  - Preparation of a detailed time frame and management of detailed work progress
  - Proposal and approval of work items within the agreed scope and terms of reference of the TSG
  - Management of work items
- The WGs are the main bodies to discuss and reach the consensus on 3GPP Technical Specifications and Technical Reports

Meeting cycles

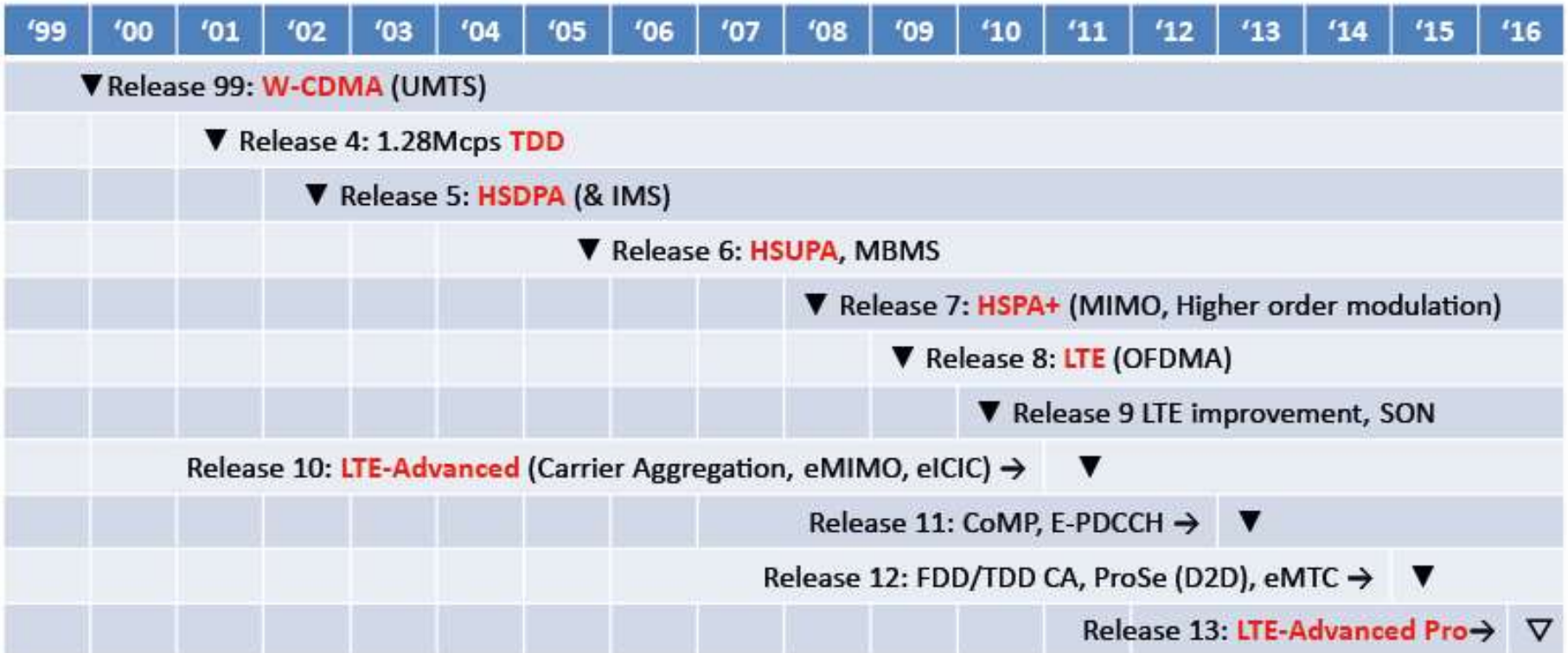


Releases

- Release: contain a group of features
- Status: Started, Ongoing, Frozen, Closed
- parallel "Releases" : provides 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
- New release every 12-18 months



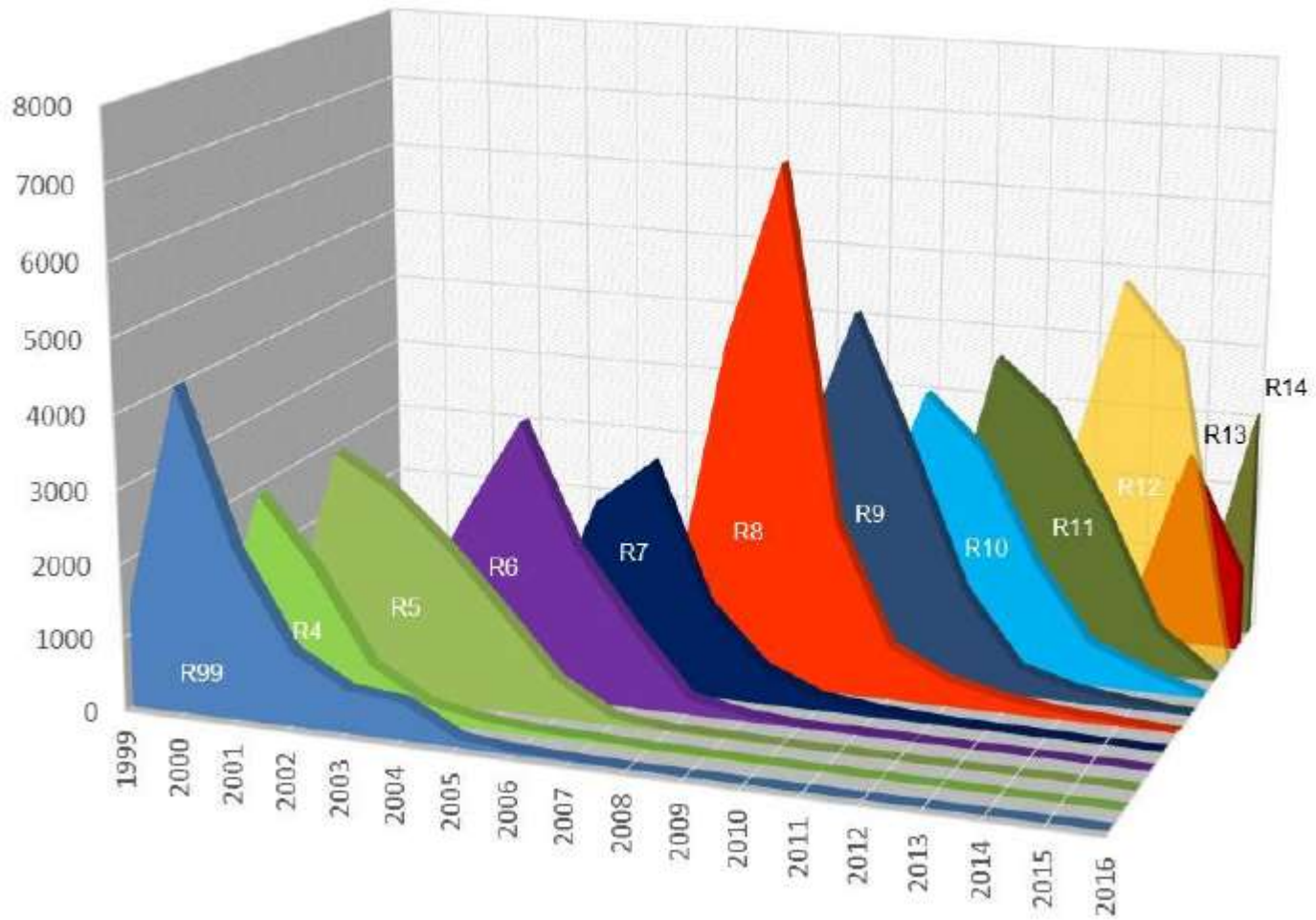
3GPP RAN Milestones



- Expanding Carrier Aggregation
- Narrowband IoT
- Elevation Beamforming/Full-Dimension (FD) MIMO for LTE
- LAA

3GPP Figures

- 600+ companies from 45 countries
- 100,000+ meeting documents per year
- 1200+ specs per release
- 10,000+ CRs per year



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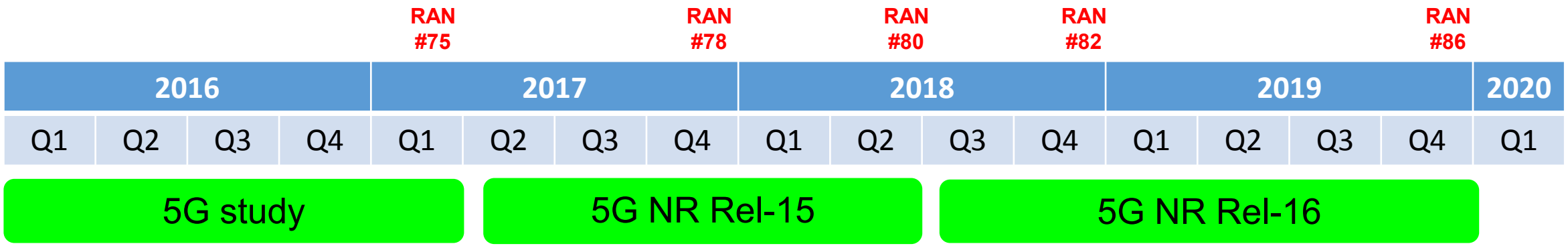
5G Timeline in 3GPP



SI & WI

- Study Item
  - Feasibility study
  - Output: Technical Report
- Work Item
  - Features
  - Output: Technical Specification
- Should be finished before a release frozen
  - Will be included in next release if not finished in time

3GPP Key 5G SIs/WIs

- Study on Scenarios and Requirements for Next Generation Access Technologies
  - Requirements study. Dec 2015 – Dec 2016
- Study on New Radio (NR) Access Technology
  - Technical study. Mar 2016 – Mar 2017
- New Radio Access Technology
  - Main WI. Mar 2017 – Dec 2018
- Study on self-evaluation towards IMT-2020 submission
  - Evaluation. Dec 2016 – Jun 2019

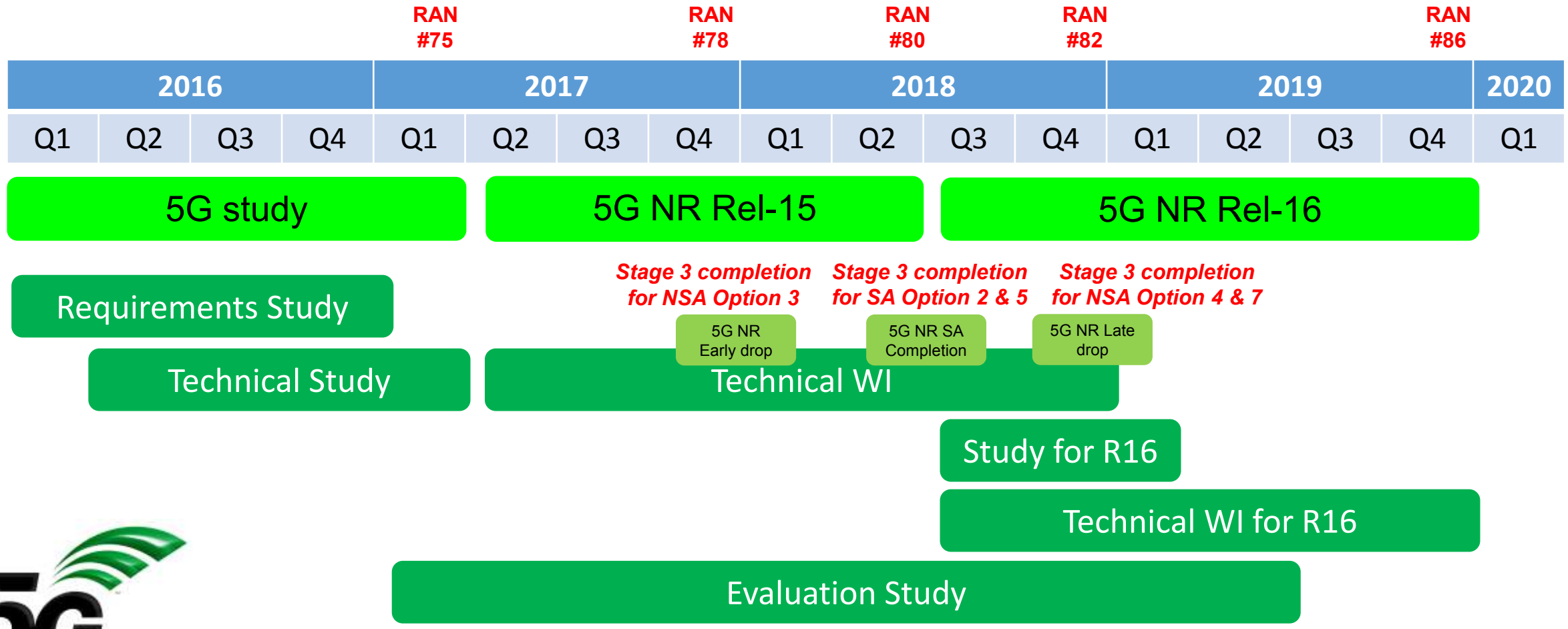
5G Phase 1 and Phase 2

- Phase 1 – Release 15
  - eMBB and ultra-reliable part of URLLC
  - Standalone and non-standalone (Dual Connectivity options)
    - Early drop: Option 3
    - Normal drop: Option 2/5
    - Late drop: Option 4/7
  - Forward compatible to Phase 2
- Phase 2 – Release 16
  - Full scenarios supported

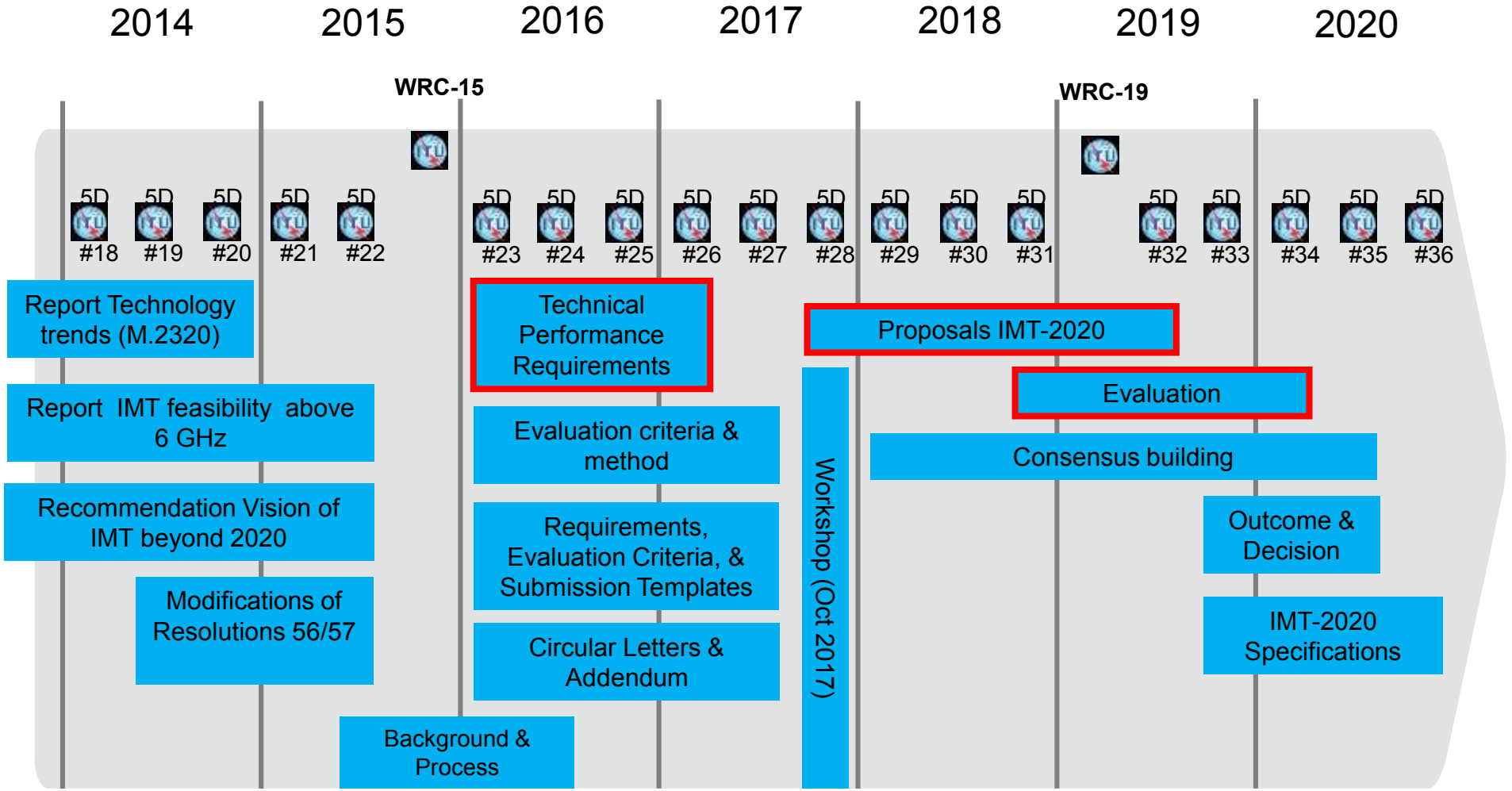
3GPP Rel-16 5G SIs/WIs

- SI
  - Study on NR Vehicle-to-Everything (V2X)
  - Study on on NR Industrial Internet of Things (IoT)
  - Study on physical layer enhancements for NR ultra-reliable and low latency case (URLLC)
  - Study on NR-based access to unlicensed spectrum
  - Study on Non-Orthogonal Multiple Access (NOMA) for NR
  - Study on integrated access and backhaul for NR
  - Study on NR positioning support
- WI
  - Enhancements on MIMO for NR
  - NR mobility enhancements
  - LTE-NR & NR-NR Dual Connectivity and NR Carrier Aggregation enhancements

5G Timeline in 3GPP

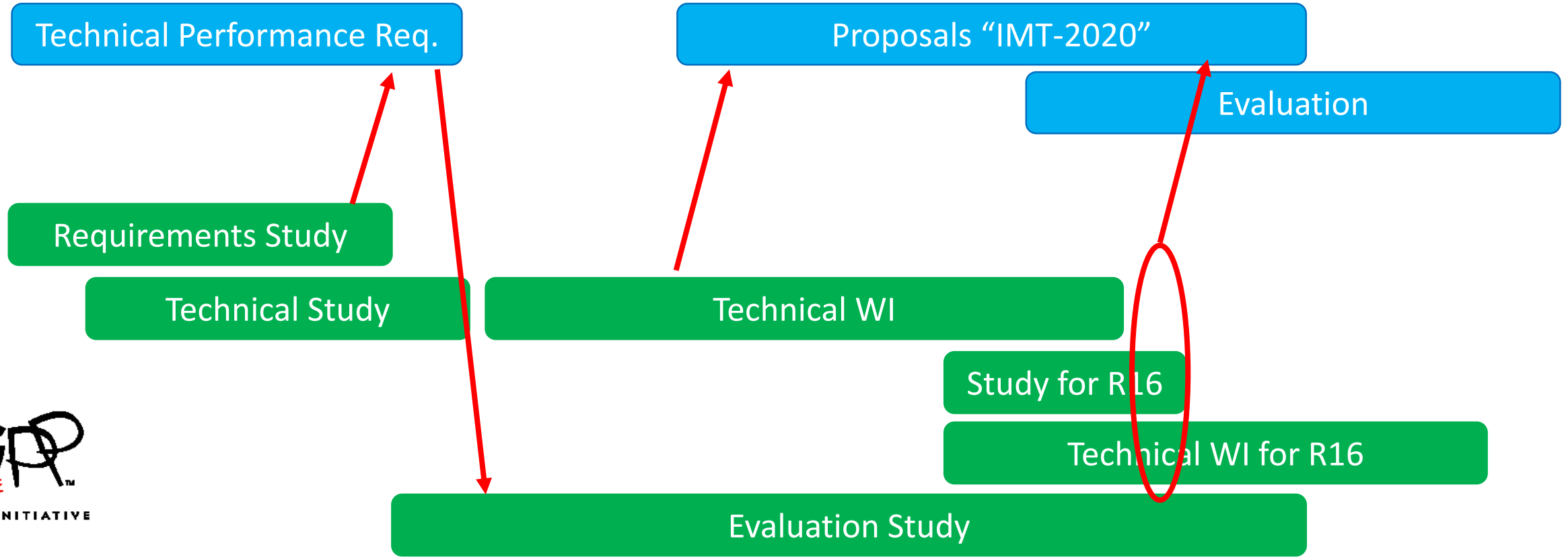


ITU Timeline for IMT-2020



5G Timeline

2016				2017				2018				2019				2020
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1



3GPP Specs

- TR 38.913 Study on scenarios and requirements for next generation access technologies
- TR 38.912 Study on new radio access technology

- TS 38.300 NR; Overall description; Stage-2
- TS 38.201 NR; Physical layer; General description
- TS 38.401 NG-RAN; Architecture description

3GPP web

- http:// www.3gpp.org
- ftp://ftp.3gpp.org or www.3gpp.org/ftp
- Specifications
  - http://www.3gpp.org/ftp/Specs/latest

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3GPP 5G Scenarios

- Indoor hotspot
  - Focuses on small coverage and high user throughput or user density in buildings
  - Key characteristics: high capacity, high user density and consistent user experience indoor
- Dense Urban
  - Focuses on macro TRxPs with or without micro TRxPs and high user densities and traffic loads in city centres and dense urban areas
  - Key characteristics: high traffic loads, outdoor and outdoor-to-indoor coverage
  - Interference-limited. Macro or macro + micro

3GPP 5G Scenarios

- Rural
  - Focuses on larger and continuous coverage
  - Key characteristics: continuous wide area coverage supporting high speed vehicles
  - Noise-limited and/or interference-limited, using macro TRxPs
- Urban macro
  - Focuses on large cells and continuous coverage
  - Key characteristics: continuous and ubiquitous coverage in urban areas
  - Interference-limited, using macro TRxPs

3GPP 5G Scenarios

- High speed
  - Focuses on continuous coverage along track in high speed trains
  - Key characteristics: consistent passenger user experience and critical train communication reliability with very high mobility
  - Macro or macro + relay nodes
- Extreme long distance coverage in low density areas
  - To provide services for very large areas with low density of users whether they are humans and machines
  - Key characteristics: Macro cells with very large area coverage supporting basic data speeds and voice services, with low to moderate user throughput and low user density
  - Isolated macro cell

3GPP 5G Scenarios

- Urban coverage for massive connection
  - Focuses on large cells and continuous coverage to provide mMTC
  - Key characteristics: high connection density of mMTC devices (continuous and ubiquitous coverage in urban areas)

3GPP 5G Scenarios

- Highway scenario
  - Focuses on scenario of vehicles placed in highways with high speeds
  - Key characteristics: reliability/availability under high speeds/mobility (and thus frequent handover operations)
- Urban Grid for Connected Car
  - Focuses on scenario of highly densely deployed vehicles placed in urban area
  - Key characteristics: reliability/availability/latency in high network load and high UE density scenarios

3GPP 5G Scenarios

- Commercial Air to Ground scenario
  - To provide services for commercial aircraft to enable both humans and machines aboard the aircraft to initiate and receive mobile services
  - Key characteristics: upward pointed Macro cells with very large area coverage supporting basic data and voice services, with moderate user throughput that are optimized for high altitude users that are travelling at very high speeds
  - Macro + relay nodes
- Light aircraft scenario
  - To provide services for general aviation aircrafts to enable both humans and machines aboard helicopters and small air plans to initiate and receive mobile services
  - Key characteristics: upward pointed Macro cells with very large area coverage supporting basic data and voice services, with moderate user throughput and low user density that are optimized for moderate altitude users that might be travelling at high speeds
  - Macro

3GPP 5G Scenarios

- Satellite extension to Terrestrial
  - To provide services for those areas where the terrestrial service is not available and also for those services that can be more efficiently supported by the satellite systems such as broadcasting service. Satellite acts as a fill-in especially on roadways and rural areas where the terrestrial service isn’t available. The supported services via the Satellite system are not limited to just data and voice, but also for others such as machine type communications, broadcast and other delay tolerant services

3GPP 5G KPIs

- Peak data rate: 20Gbps for downlink, 10Gbps for uplink
- Peak spectral efficiency: 30bps/Hz for downlink, 15bps/Hz for uplink
- Control plane latency: 10ms
- User plane latency
  - eMBB: 4ms for UL, 4ms for DL
  - URLLC: 0.5ms for UL, 0.5ms for DL
- Mobility interruption time: 0ms
- Spectrum efficiency: 3x (eMBB)

3GPP 5G KPIs

- Reliability
  - URLLC: $1*10^{-5}$ (32 bytes with a user plane latency of 1ms)
  - eV2X: $1*10^{-5}$ (300 bytes with a user plane latency of 3-10ms)
- UE battery life
  - mMTC: beyond 10 years, 15 years desirable (200 bytes UL per day, 5Wh)
- Connection density: 1 000 000 device/km^2 in urban environment
- Mobility: 500 km/h

3GPP 5G Other Requirements

- Architecture
  - Tight interworking with LTE -> Architecture options
  - Allow C-plane/U-plane separation -> CP/UP speration
  - Allow for the operation of Network Slicing -> Slicing
- Operation requirement
  - Bandwidth scalability -> BWP
  - UL Link Budget -> SUL

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