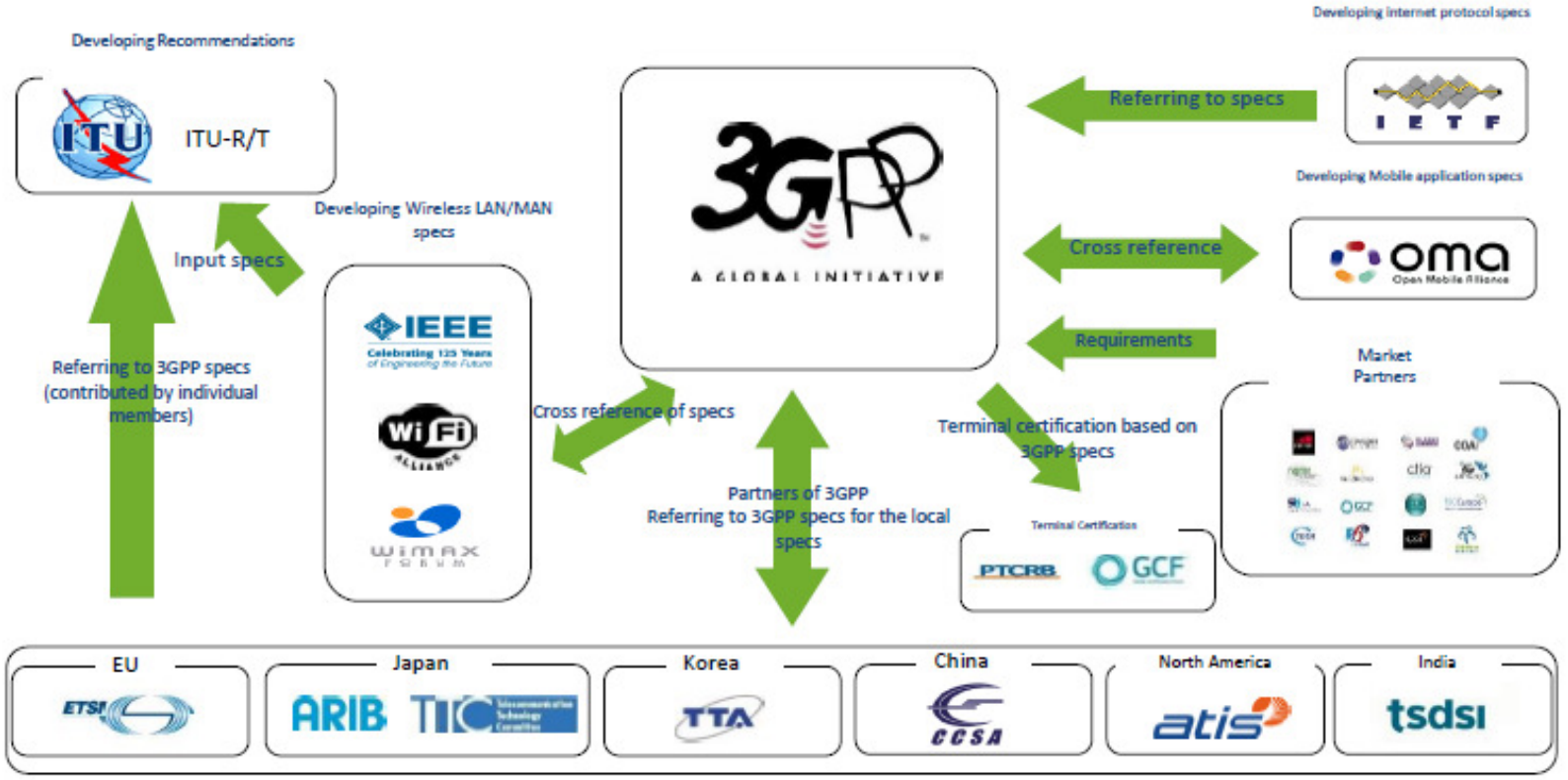
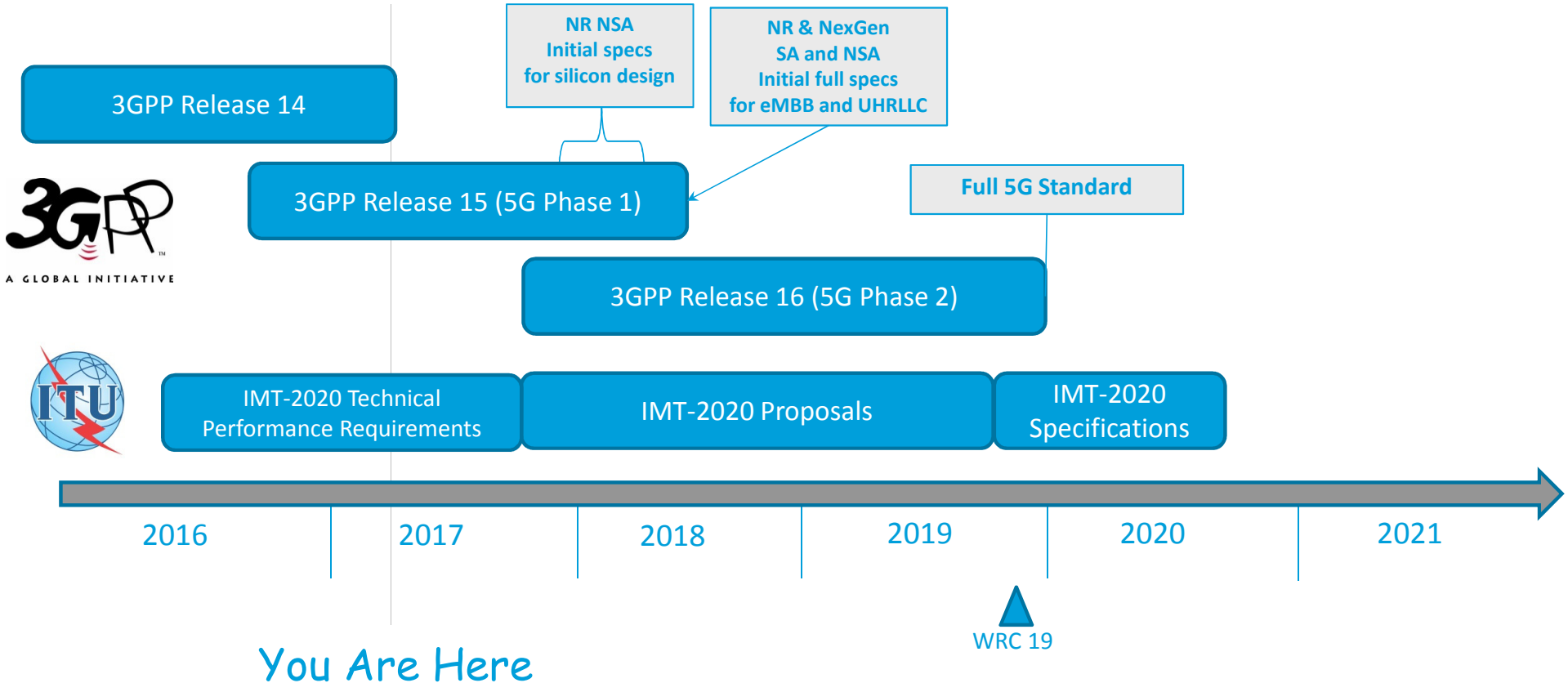
3GPP Ecosystem

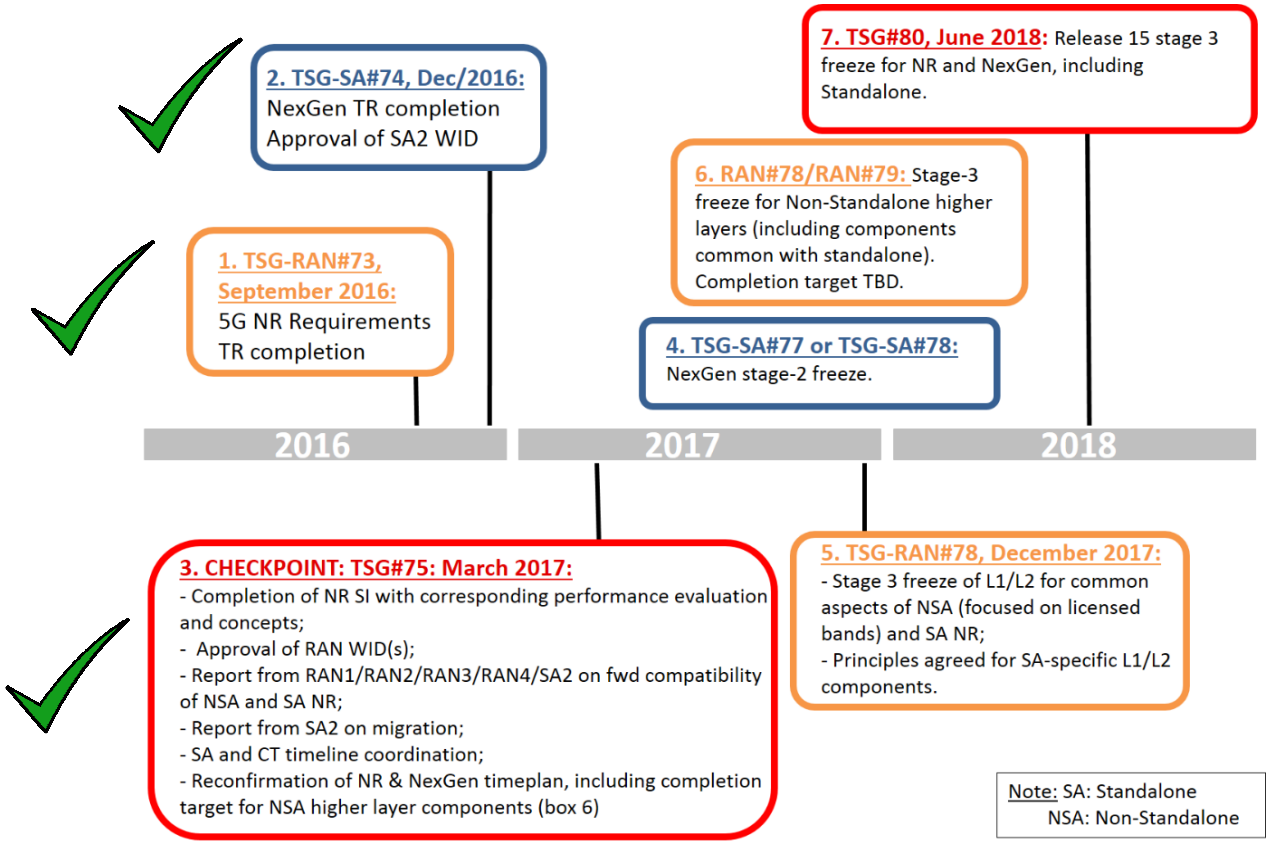


Source: 3GPP

Projected Industry 5G Standards Timelines



3GPP Release 15 Workplan



Source: 3GPP

3GPP - March 2017 SA plenary meetings

SA1 Technical Specification (TS) on 5G was approved (90% complete)

- TS 22.261 on Service requirements for next generation new services and markets (SMARTER/5G), Version 2.0.0
- Normative Stage 1 requirements for next generation mobile telecommunications
- Outstanding requirements will be completed by June, the stage 1 target freeze for 5G Phase 1

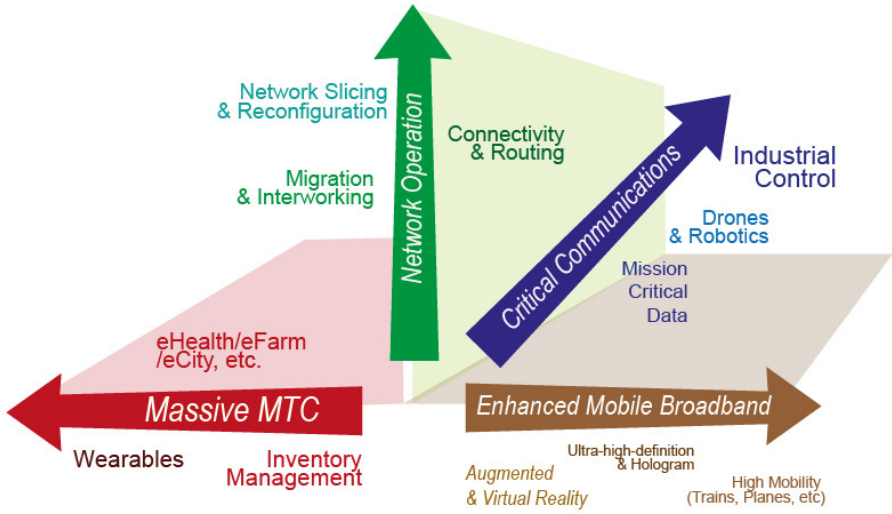
SA2 (Architecture) and SA3 (Security) Work Item for Acceleration (Option 3) was approved

- "New WID on EPC enhancements to support 5G New Radio via Dual Connectivity"
- Security → Ensure that user plane traffic (and control plane signaling) has at least the same level of protection as E-UTRAN (LTE)
- Target completion is September 2017
- SA2 to start work in March meeting

SA2 indicates to RAN/SA no issue with migration from option 3 to 5G CN

RAN/SA agree to explore how to make (R)AN-CN interface access agnostic

TS 22.186 on Enhancement of 3GPP Support for V2X Scenarios (eV2X), Version 1.0.1 (Note: This is for 5G and LTE)



Source: 3GPP

3GPP Release 15 NR Acceleration for eMBB

Major decision was taken in March 3GPP RAN plenary on the 5G New Radio (NR) workplan

Agreed on intermediate milestone for early completion of the Non-standalone (NSA) 5G NR mode for enhanced Mobile BroadBand (eMBB) use-case

- Non-standalone mode the connection is anchored in LTE while 5G NR carriers are used to boost data-rates and reduce latency

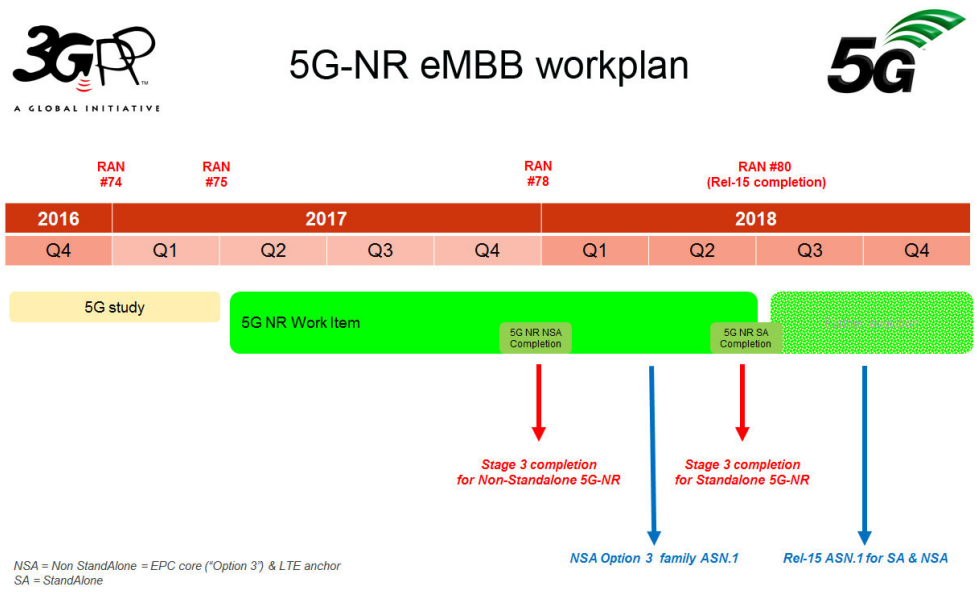
Ensure commonality with Standalone eMBB (incl. low latency support), as well as forward compatibility

Ensure alignment of core network aspects

- 3GPP SA and CT: completion of stage-3 for "Option 3" family by December 2017 in case modifications to the current specifications are needed
- Overall 5G "NextGen" Core Network already agreed to be completed by June 2018

Maintain current schedule for Standalone 5G-NR in Rel-15

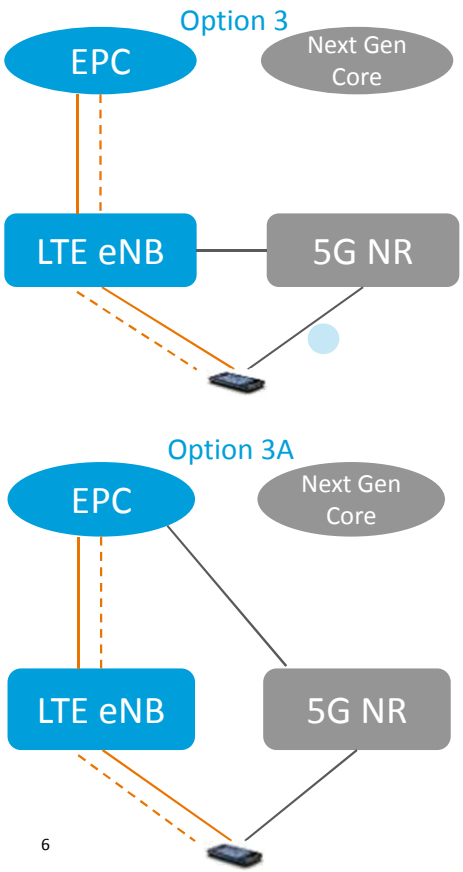
- Stage 3 completion June 2018; ASN.1 freeze September 2018



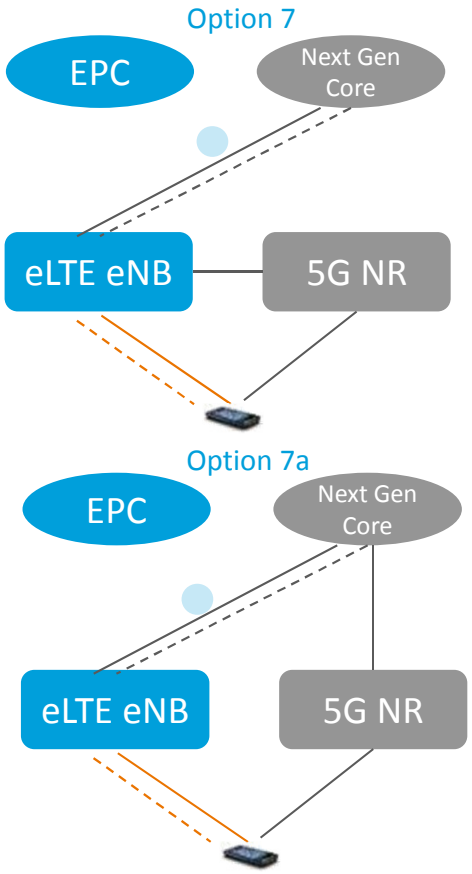
Source: 3GPP

3GPP 5G Architecture Options

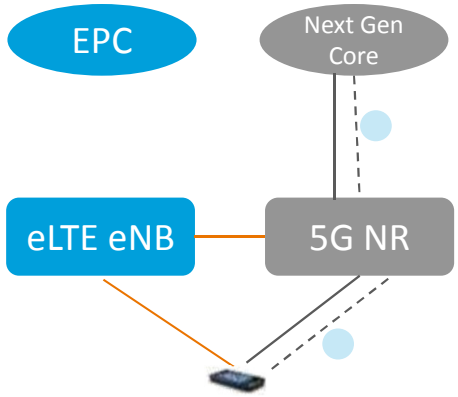
Option 3/3A: Non-Standalone
/LTE assisted, EPC connected



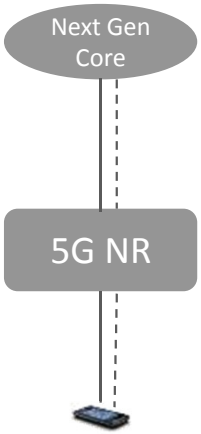
Option 7/7a: Non-Standalone
/LTE assisted, NGCN connected



Option 4: Non-Standalone
/NR assisted, NGCN connected



Option 2: Standalone NR, NGCN connected



LTE-5G NR Dual Connectivity is required for option 3/3A/7/7a/4

LTE C-plane
LTE U-plane
5G C-plane
5G U-plane

What's new?

Key 3GPP Release 15 Phase 1 Approved SA/CT Work Items

EPC enhancements to support 5G New Radio via Dual Connectivity; rel-15 (SP-170233)

- Mechanism for HPLMN and VPLMN control of access to 5G NR (in particular when 5G NR is used as a Secondary RAT)
- Alignment of SA2 specifications with work in TSG RAN and RAN WGs for EPC-based Dual Connectivity
- Security → Any work needed to ensure that user plane traffic (and control plane signaling) has at least the same level of protection as in E-UTRAN

5G System Security Architecture-Phase 1 ; Rel-15 (SP-17024)

- Security Architecture and Procedures for 5G System
- Specifies the overall security architecture, security features and security procedures between UE and 5G System

Key 3GPP Release 15 Phase 1 Approved SA/CT Work Items

Enhancement of 3GPP support for V2X scenarios; Rel-15 (SP-170158)

- Specify service requirements to enhance 3GPP support for V2X scenarios valid for the 3GPP systems (i.e. 5G system, EPS) for the following areas:
  - Vehicle Platooning; Advanced Driving; Extended Sensors; Remote Driving
  - General Aspects: interworking, communication-related requirements
- Transport layer support for:
  - Safety-related V2X scenarios: e.g. automated driving, vehicle platooning
  - Non-safety-related V2X scenarios: e.g., mobile high data rate entertainment, mobile hotspot/office/home, dynamic digital map update
  - Support for V2X scenarios in multiple network environment, where interoperability with non-3GPP V2X technologies (e.g. ITS G5/DSRC/ITS Connect) may be included.
- Note: This is for 5G and LTE

Key 3GPP Release 15 SA/CT Approved Study Items (will help define Release 16)

Study on Common API Framework for 3GPP Northbound APIs; Rel-15 (SP-170279)

- Identify architecture requirements for a common API framework for use by northbound entities
- Identity management of northbound entities; security, including (mutual) authentication and authorization of northbound entities; configuration and access control policy enforcement; registration and discovery of APIs; event subscription/notification and API usage models; aspects relevant to interactions between the framework and functional APIs (e.g. pre-emption, priority, QoS, etc.)
- Investigate existing API frameworks outside 3GPP e.g. OMA Net APIs, ETSI MEC, identifying any gaps, for potential re-use and harmonization of API development efforts across SDOs
- Note: This is for 5G and LTE

Study on Charging Aspects of 5G System Architecture Phase 1; Rel-15 (SP-170128)

- Study the charging architecture and solutions to support the 5G System Architecture and key features Phase 1 and the evolution of charging mechanisms and charging models to support the Third Parties

CT aspects on 5G System - Phase 1; Rel-15 (SP-170238)

- Study and later specify the core-network and terminal protocol aspects of the 5G system work based on the requirements work developed by SA1, architecture work developed by SA2, security requirements developed by SA3, and new radio access technologies developed by RAN

Key 3GPP Release 15 Phase 1 Approved RAN Work Items

- New WID on New Radio Access Technology (RP-170847)
  - 57 supporting companies on the final WID
  - Physical layer aspects and procedures, NR-LTE coexistence, UE categories/capabilities, RAN architecture, carrier aggregation, inter-RAT mobility, etc.
  - Includes both eMBB and UHRLLC use cases
  - Note mIoT/mMTC is in Release 16 (Release 15 LTE NB-IoT and eMTC support this use case)

- New WID on CU-DU lower layer split for New Radio (RP-170818)
  - Splitting the RAN architecture into CU (Centralized Unit) and DU (Distributed Unit)

- New WID on LTE connectivity to 5G-CN (RP-170840)
  - Specify E-UTRA protocols enhancement to support 5G-CN functions as (RAN2) e.g. Network slicing; Flow based QoS framework, including potential enhancement for the dual connectivity between eNBs using flow based QoS; New security scheme (if any)
  - Allow simultaneous support of UEs connected to EPC and UEs connected to 5G-CN in the same LTE cell
  - Support handover between LTE cells connected to the EPC and LTE cells connected to the 5G-CN

Key 3GPP Release 15 RAN Approved Study Items (will help define Release 16)

Study on NR to support Non-Terrestrial Networks (RP-170717)

- Non-terrestrial networks refer to networks, or segments of networks, using an airborne or space-borne vehicle for transmission:
- Space-borne vehicles: Satellites (including Low Earth Orbiting (LEO) satellites, Medium Earth Orbiting (MEO) satellites, Geostationary Earth Orbiting (GEO) satellites as well as Highly Elliptical Orbiting (HEO) satellites)
- Airborne vehicles: Unmanned Aircraft Systems (UAS) including tethered UAS and Lighter than Air UAS (LTA), Heavier than Air UAS (HTA), High Altitude UAS Platforms (HAPs)
- Study the feasibility of adapting the 3GPP channel model for non-terrestrial networks, and identify/study new channel models
- Deployment scenarios

Study on NR-based Access to Unlicensed Spectrum (RP-170828)

- NR-based operation in unlicensed spectrum
- Scenarios:
  - An NR-based LAA cell(s) connects with an LTE or NR anchor cell operating in licensed spectrum
  - An NR-based cell operating standalone in unlicensed spectrum, connected to a 5G-CN network with priority on frequency bands above 6GHz, e.g., for private network deployments
  - how to ensure from a RAN level that connection and security management can be integrated with the E-UTRAN, NG RAN and 5G CN architecture, including service continuity requirements for users moving between cells of licensed and unlicensed frequency bands

Key 3GPP Release 15 RAN Approved Study Items (will help define Release 16)

Study on 5G Non-Orthogonal Multiple Access (RP-170829)

- Rel-14 Study Item identified that NR should at least target UL non-orthogonal multiple access at least for mMTC
- Requires high computational power to implement real-time power allocation and successive interference cancellation algorithms
- By 2020, the time that 5G networks are targeted to be deployed, the computational capacity of both handsets and access points is expected to high enough to run NOMA algorithms
- Benefits of non-orthogonal multiple access, particularly when enabling grant-free transmission, may encompass a variety of use cases or deployment scenarios, including eMBB, URLLC, mMTC etc.

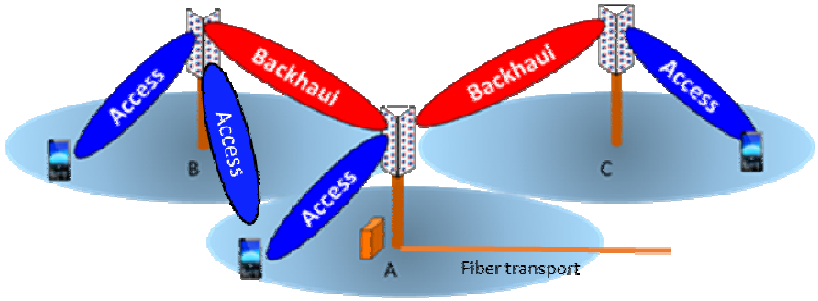
Study on evaluation methodology of new V2X use cases for LTE and NR (RP-170837)

- Evaluating technical solutions to support the full set of 5G V2X use cases as identified in TR 22.886
- Vehicles Platoonning; Extended Sensors; Advanced Driving (semi-automated or full-automated driving); Remote Driving
- Evaluation scenarios including performance metric, vehicle dropping, traffic model; Sidelink channel model for spectrum above 6 GHz
- Regulatory requirements and design considerations of potential operation of direct communications between vehicles in spectrum allocated to ITS beyond 6GHz in different regions, considering at least 63-64GHz (allocated for ITS in Europe) and 76-81GHz depending on regulatory decision

Key 3GPP Release 15 RAN Approved Study Items (will help define Release 16)

Integrated access and backhaul for NR (RP-170831)

- Support for wireless backhaul and relay links enabling flexible and very dense deployment of NR cells without the need for densifying the transport network proportionately
- Immediate need for integrated access and backhaul (IAB)
- Delaying work on this feature could have a detrimental impact on the timely rollout of 5G/NR networks, in particular those networks which use millimeter wave spectrum



Study of test methods for New Radio (RP-170824)

- Testability for mmWave NR is beneficial to the overall progress of NR standardization and to the accelerated empowerment of test houses and developer labs to implement these test solutions

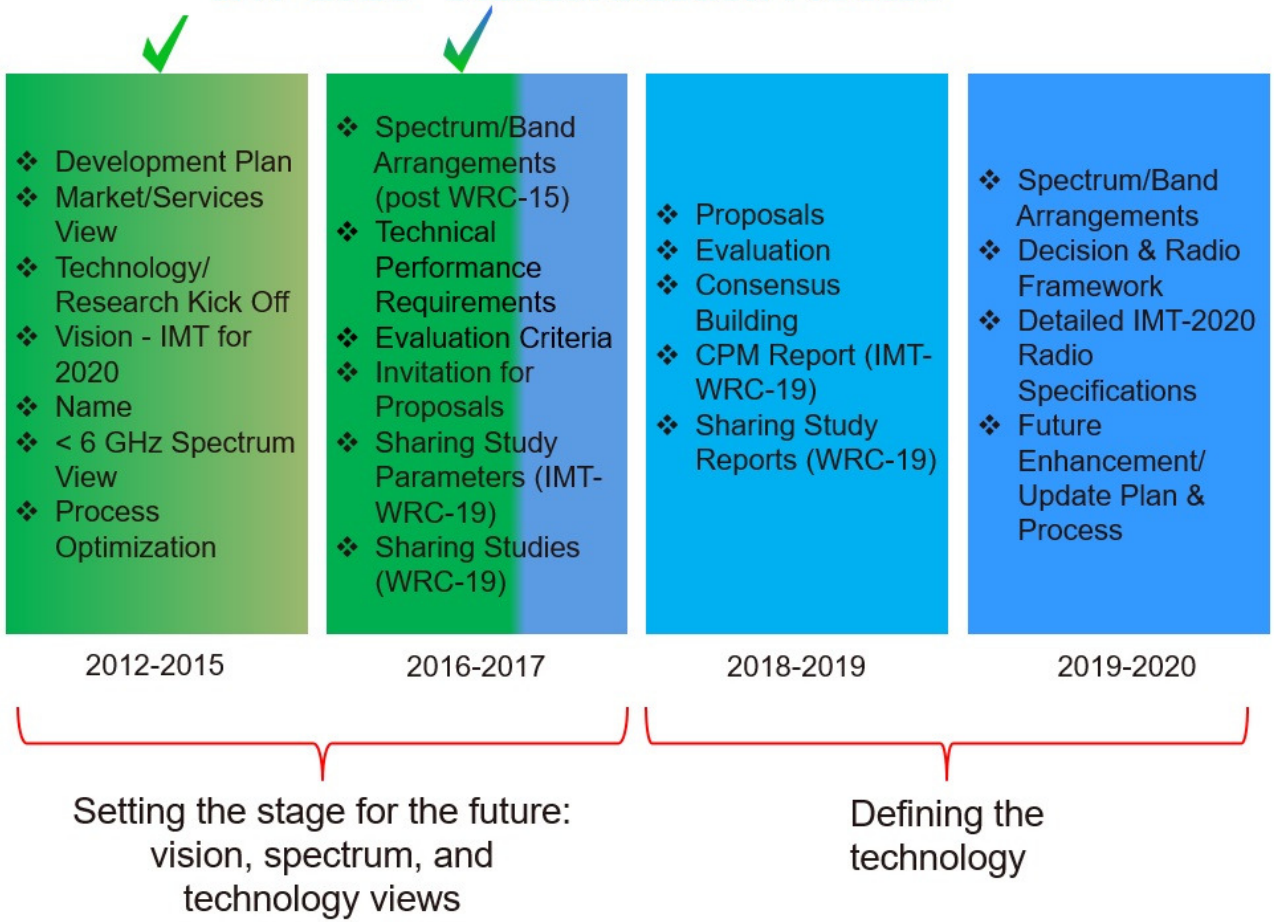
Study on Self Evaluation towards IMT-2020 submission (RP-170832)

- Provide self evaluation results towards IMT-2020 submission to ITU-R WP 5D against the technical performance requirements defined by Report ITU-R M.[IMT-2020. TECH PERF REQ]

3GPP 5G Technical Reports (Release 14)

- Skeleton TR 38.805 v0.0.1 “Study on New Radio Access Technology; 60 GHz Unlicensed Spectrum”
- TR 38.802 v2.0.0 on Study on New Radio (NR) Access Technology Physical Layer Aspects
- TR 38.803 v2.0.0 on Study on New Radio Access Technology: RF and co-existence aspects
- TR 38.804 v1.0.0 on Study on New Radio Access Technology; Radio Interface Protocol Aspects
- TR 38.801 v2.0.0 on Study on New Radio Access Technology; Radio Access Architecture and Interfaces
- TR 38.901 v1.0.1 Study on channel model for frequencies from 0.5 to 100 GHz
- TR 38.805 v1.0.0 “Study on New Radio Access Technology; 60 GHz Unlicensed Spectrum”

"IMT-2020" Standardization Process



Source: ITU

ITU IMT-2020 Technical Performance Requirements

Draft new Report ITU-R M.[IMT-2020. TECH PERF REQ] completed February 2017

- Expected final approved by ITU-R Study Group 5 at its next meeting in November 2017
- Key minimum technical performance requirements defined for the purpose of:
  - Consistent definition, specification, and evaluation of the candidate IMT-2020 radio interface technologies (RITs)/Set of radio interface technologies (SRIT) in conjunction with the development of ITU-R Recommendations and Reports
- Intent is to ensure that IMT-2020 technologies are able to fulfil the objectives of IMT-2020 and to set a specific level of performance that each proposed RIT/SRIT needs to achieve in order to be considered by ITU-R for IMT-2020

IMT-2020 Technical Performance Requirements - Summary

Peak data rate

- Maximum achievable data rate under ideal conditions (in bit/s)
- Rp = W × Sep (W=channel bandwidth, Sep = peak spectral efficiency in that band)
  - Can also aggregate over multiple bands
- The minimum requirements for peak data rate are as follows:
  - Downlink peak data rate is 20 Gbit/s
  - Uplink peak data rate is 10 Gbit/s

Peak spectral efficiency

- Maximum data rate under ideal conditions normalized by channel bandwidth (in bit/s/Hz)
- The minimum requirements for peak spectral efficiencies are as follows:
  - Downlink peak spectral efficiency is 30 bit/s/Hz
  - Uplink peak spectral efficiency is 15 bit/s/Hz

IMT-2020 Technical Performance Requirements - Summary

User experienced data rate

- 5% point of the cumulative distribution function (CDF) of the user throughput
- User throughput (during active time) is defined as the number of correctly received bits, i.e. the number of bits contained in the service data units (SDUs) delivered to Layer 3, over a certain period of time.
- The target values for the user experienced data rate are as follows in the Dense Urban – eMBB test environment:
  - Downlink user experienced data rate is 100 Mbit/s.
  - Uplink user experienced data rate is 50 Mbit/s.

IMT-2020 Technical Performance Requirements - Summary

Area traffic capacity

- Total traffic throughput served per geographic area (in Mbit/s/m2)
- Area traffic capacity area is related to average spectral efficiency: $C_{area} = \rho \times W \times S_{eavg}$
- Target value for Area traffic capacity in downlink is 10 Mbit/s/m2 in the Indoor Hotspot – eMBB test environment

User plane latency

- Contribution of the radio network to the time from when the source sends a packet to when the destination receives it (in ms)
- The minimum requirements for user plane latency are:
  - 4 ms for eMBB
  - 1 ms for URLLC
  - assuming unloaded conditions (i.e., a single user) for small IP packets (e.g., 0 byte payload + IP header), for both downlink and uplink.

IMT-2020 Technical Performance Requirements - Summary

Control plane latency

- Transition time from a most “battery efficient” state (e.g. Idle state) to the start of continuous data transfer (e.g. Active state)
- The minimum requirement for control plane latency is 20 ms.
  - Proponents are encouraged to consider lower control plane latency, e.g. 10 ms.

Connection density

- Total number of devices fulfilling a specific quality of service (QoS) per unit area (per km2)
- The minimum requirement for connection density is 1,000,000 devices per km2
  - Supports the mIoT use case

IMT-2020 Technical Performance Requirements - Summary

Energy Efficiency

- Network energy efficiency is the capability to minimize the radio access network energy consumption in relation to the traffic capacity provided
- Device energy efficiency is the capability to minimize the power consumed by the device modem in relation to the traffic characteristics
- Low energy consumption when there is no data can be estimated by the sleep ratio
  - Sleep ratio is the fraction of unoccupied time resources (for the network) or sleeping time (for the device) in a period of time corresponding to the cycle of the control signaling (for the network) or the cycle of discontinuous reception (for the device) when no user data transfer takes place
  - Sleep duration, i.e. the continuous period of time with no transmission (for network and device) and reception (for the device), should be sufficiently long
- Shall have the capability to support a high sleep ratio and long sleep duration
  - Proponents are encouraged to describe other mechanisms of the RIT/SRIT that improve the support of energy efficient operation for both network and device

IMT-2020 Technical Performance Requirements - Summary

Reliability

- Capability of transmitting a given amount of traffic within a predetermined time duration with high success probability
- The minimum requirement for the reliability is 1*10-5 success probability of transmitting a layer 2 PDU (protocol data unit) of 32 bytes within 1 ms in channel quality of coverage edge for the Urban Macro-URLLC test environment, assuming small application data (e.g. 20 bytes application data + protocol overhead).
  - Proponents are encouraged to consider larger packet sizes, e.g. layer 2 PDU size of up to 100 bytes

Mobility

- Maximum mobile station speed at which a defined QoS can be achieved (in km/h)
- The following classes of mobility are defined:
  - Stationary: 0 km/h
  - Pedestrian: 0 km/h to 10 km/h
  - Vehicular: 10 km/h to 120 km/h
  - High speed vehicular: 120 km/h to 500 km/h

TABLE 3

Mobility classes

	Test environments for eMBB		
	Indoor Hotspot – eMBB	**Dense Urban – eMBB**	**Rural – eMBB**
Mobility classes supported	Stationary, Pedestrian	Stationary, Pedestrian, Vehicular (up to 30 km/h)	Pedestrian, Vehicular, High speed vehicular

IMT-2020 Technical Performance Requirements - Summary

Bandwidth

- Maximum aggregated system bandwidth
- The bandwidth may be supported by single or multiple radio frequency (RF) carriers
- The requirement for bandwidth is at least 100 MHz
- Shall support bandwidths up to 1 GHz for operation in higher frequency bands (e.g. above 6 GHz)
- Shall support scalable bandwidth
  - Scalable bandwidth is the ability of the candidate RIT/SRIT to operate with different bandwidths