5G R15 standardization

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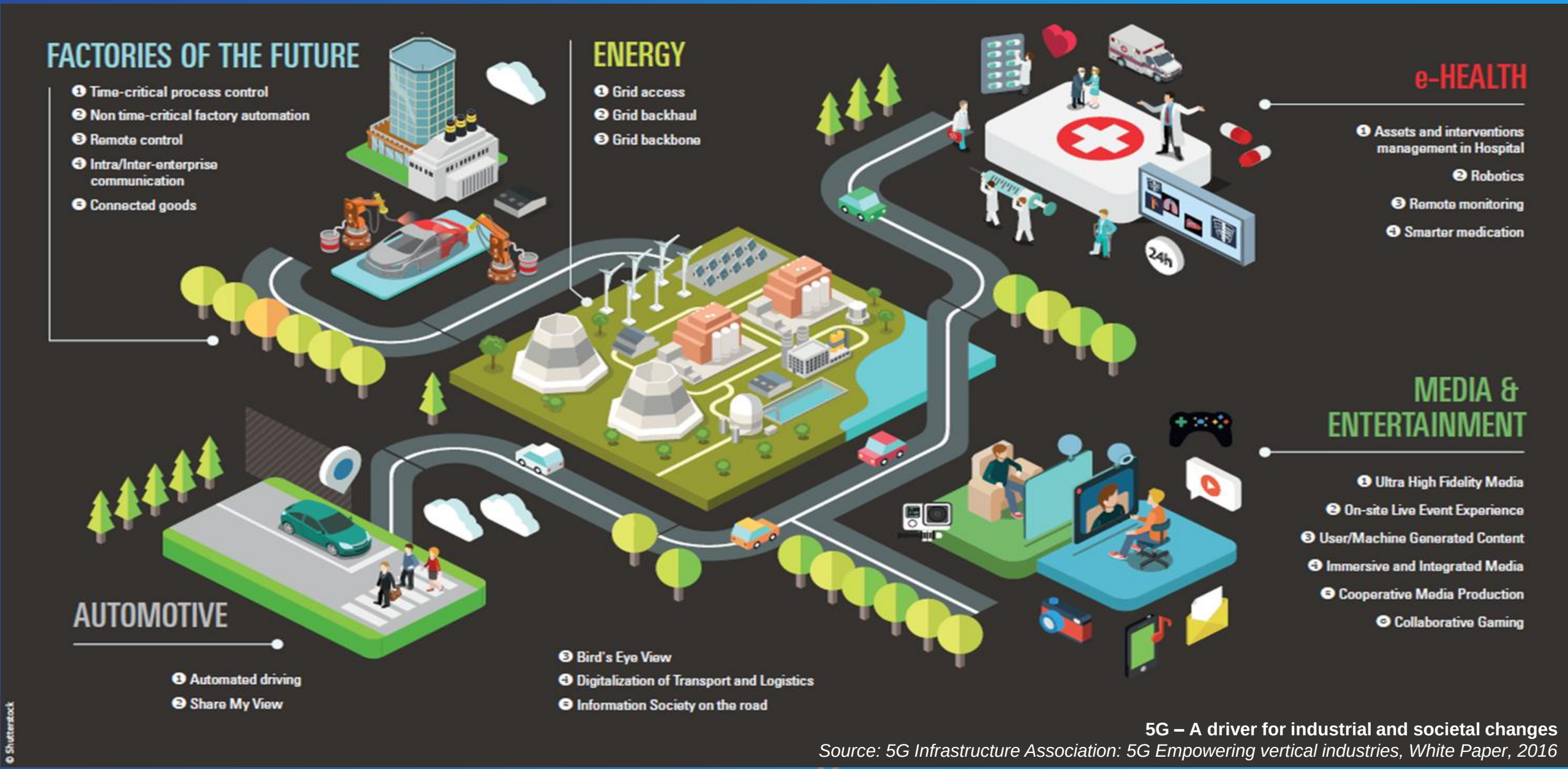
Outline

- 3GPP structure
- 5G architecture
- 5G RAN
- 5G time line and status
- Way forward

5G will be a toolbox for empowering the networked society



5G – A driver for industrial and societal changes

Source: 5G Infrastructure Association: 5G Empowering vertical industries, White Paper, 2016

3GPP structure

Project Co-ordination Group (PCG)

TSG RAN Radio Access Network	**TSG SA** Service & Systems Aspects	**TSG CT** Core Network & Terminals
RAN WG1 Radio Layer 1 spec	SA WG1 Services	CT WG1 MM/CC/SM (Iu)
RAN WG2 Radio Layer 2 spec Radio Layer 3 RR spec	SA WG2 Architecture	CT WG3 Interworking with external networks
RAN WG3 Iub spec, Iur spec, Iu spec UTRAN O&M requirements	SA WG3 Security	CT WG4 MAP/GTP/BCH/SS
RAN WG4 Radio Performance Protocol aspects	SA WG4 Codec	CT WG6 Smart Card Application Aspects
RAN WG5 Mobile Terminal Conformance Testing	SA WG5 Telecom Management	
RAN WG6 Legacy RAN radio and protocol	SA WG6 Mission-critical applications	

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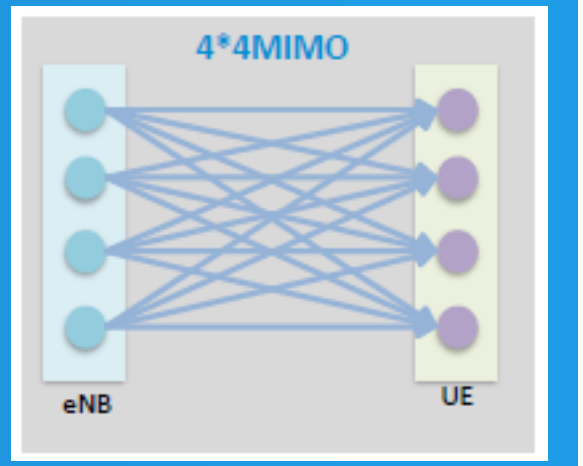
5G System Architecture

- 5G network architecture
  - Optimized for different use-cases enabled by native support for NFV (‘network slicing’)
  - Core network shall be access agnostic
  - Highly distributed architecture
  - Dependent of good, extensive transport infrastructure
  - Priority, QoS will be essential for supporting services with very different characteristics
  - IMS (more or less unmodified) still the service engine
- The architecture is more modular. However, not revolutionary, rather an evolution from rel. 14 CUPS (Control-Plane User-Plane Separation).

5G Access network

- Long term 5G is about more than the New Radio (NR), but:
  - A new radio interface will be defined for 5G
  - Massive MIMO
  - Flexible and more spectrum efficient than 4G.
  - Spectrum from sub 1GHz to 100GHz, even unlicensed
  - FDD operation in paired bands
  - TDD operations in unpaired bands
  - Tight interworking LTE and NR
  - Both NR and LTE-A Pro candidates for IMT-2020



New ITU Report on IMT-2020 Minimum Requirements

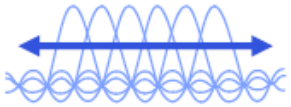
Metric	Requirement	Comments
Peak Data Rate	DL: **20 Gbps** UL: 10 Gbps	Single eMBB mobile in ideal scenarios assuming all resources utilized
Peak Spectral Efficiency	DL: **30 bps/Hz** (assuming 8 streams) UL: 15 bps/Hz (assuming 4 streams)	Single eMBB mobile in ideal scenarios assuming all resources utilized
User Experienced Data Rate	DL: 100 Mbps UL: 50 Mbps	5% CDF of the eMBB user throughput
Area Traffic Capacity	Indoor hotspot DL: 10 Mbps/m^2	eMBB
User plane latency	eMBB: 4ms URLLC: **1ms**	Single user for small IP packets, for both DL and UL (eMBB and URLLC)
Control plane latency	20ms (encouraged to consider **10ms**)	Transition from Idle to Active (eMBB and URLLC)
Connection Density	1M devices per km^2	For mMTC
Reliability	99.9999% success prob.	32 L2 bytes within 1ms at cell edge
Bandwidth	>100 MHz; up to **1 GHz in > 6 GHz**	Carrier aggregation allowed

DRAFT NEW REPORT ITU-R M.[IMT-2020.TECH PERF REQ], "Minimum requirements related to technical performance for IMT-2020 radio interface(s)," Document 5/40-E, 22 February 2017

3GPP Rel-15 establishes a solid foundation for 5G NR

For enhanced mobile broadband and beyond

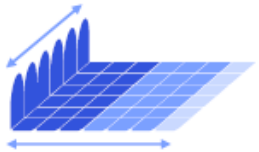
Scalable OFDM-based air interface



Scalable OFDM numerology

Efficiently address diverse spectrum, deployments and services

Flexible slot-based framework



Self-contained slot structure

Key enabler to low latency, URLLC and forward compatibility

Advanced channel coding

ME-LDPC and CA-Polar[1]

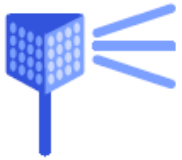
Efficiently support large data blocks and a reliable control channel

Massive MIMO

Reciprocity-based MU-MIMO

Efficiently utilize a large # of antennas to increase coverage / capacity

Mobile mmWave

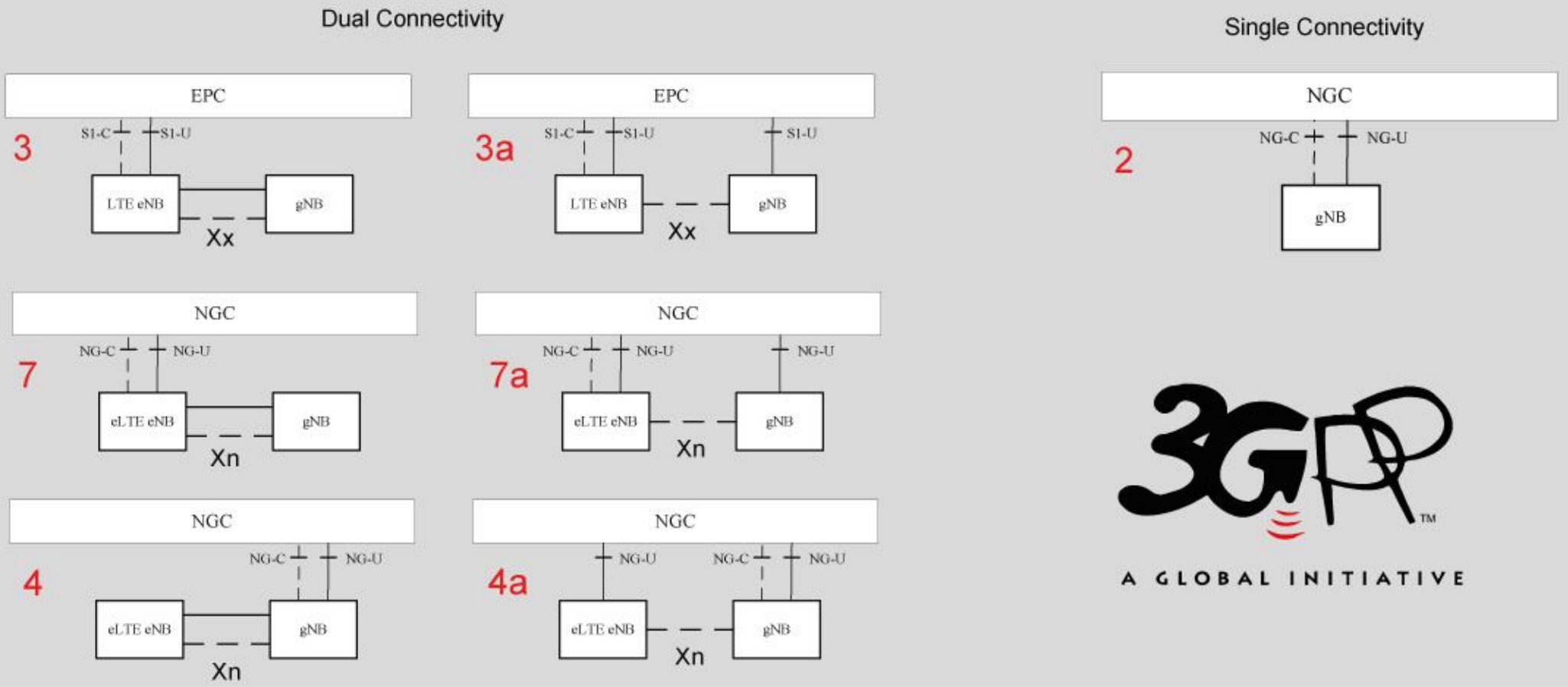


Beamforming and beam-tracking

Enables wide mmWave bandwidths for extreme capacity and throughput

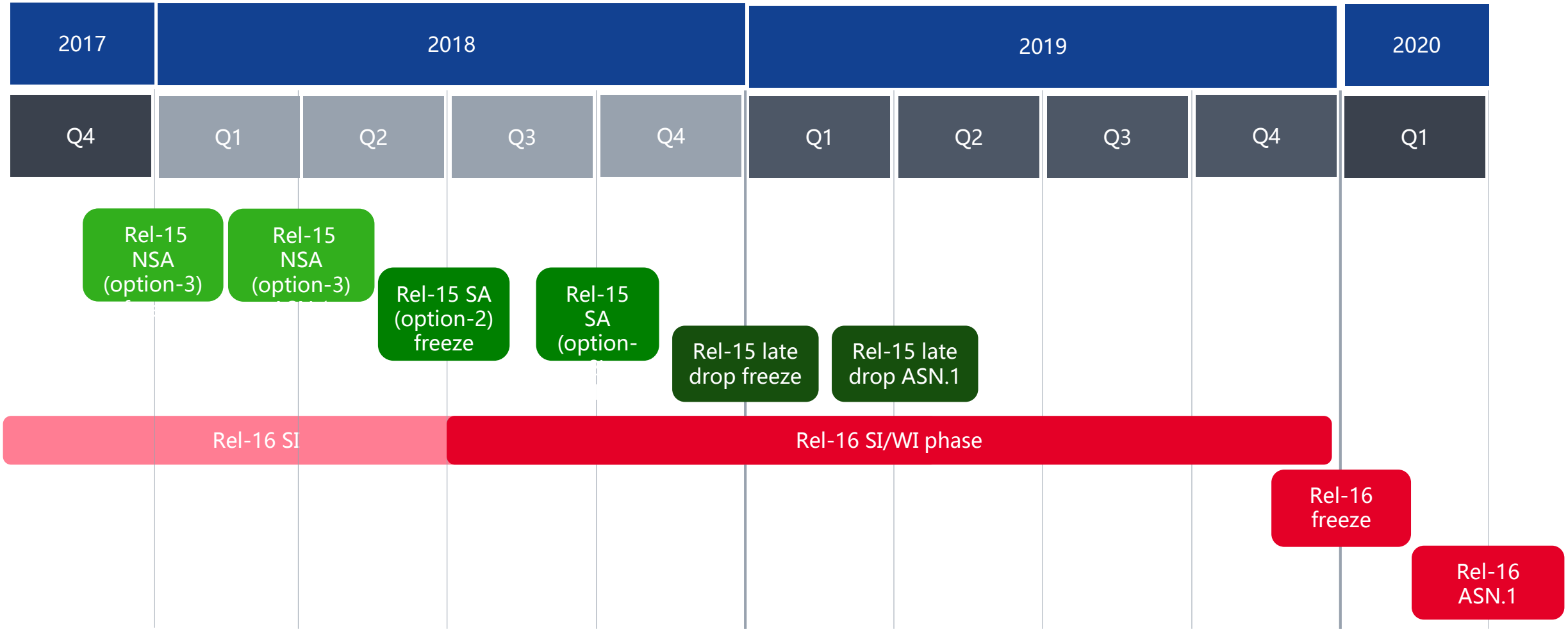
Source: Qualcomm

New RAN Architecture Options



http://www.3gpp.org/news-events/3gpp-news/1929-nsa_nr_5g

3GPP standardization timeline



From RAN chairman's report after RAN#79:
Release timeline unchanged

- Rel-15 schedule unchanged
  - Architecture Option 3: ASN.1 Freeze March 2018
    - RAN#79 endorsed the freeze of NSA ASN.1 and approved the corresponding CRs
  - Architecture Option 2: ASN.1 Freeze September 2018
  - Architecture Option 5: ASN.1 Freeze September 2018 (only impacts LTE ASN.1)
  - Priorities unchanged: Until June WGs shall prioritize Option-3 stabilization (only essential corrections allowed), and on Option-2 specification work
- Rel-16 schedule unchanged
  - Approval of the main package of SIs/WIs to be done in June/2018 as already planned
    - Approval of further urgent items at a later stage shall still be possible
  - TU and project planning of all SIs/WIs (already approved ones and newly approved ones) will be done together as a package in June/2018 and adjusted in subsequent RAN plenary meetings

From RAN chairman's report after RAN#79:
Late drop for Rel-15

- Introduce a late drop for Rel-15 that follows Rel-15 completion by 6 months
- The late drop is to exclusively contain NR architecture options that were not completed by September ASN.1 drop
  - Options 4, 7 are part of the late drop
  - NR-NR DC to be considered to be added to the late drop at RAN#80
    - Scope to target minimum RAN1 impact, scope to be addressed at RAN#80
    - NR-NR DC band combinations (limited to FR1-FR2) can be proposed in RAN4 in Q2, pending final approval at RAN#80
    - No other WG work to proceed specifically on NR-NR DC in Q2
  - Hardware impacts for the late drop should be avoided
  - After RAN#79, no further functionality will be considered to be included in the late drop
  - Band combinations which are not completed by June 2018 (other than NR-NR DC combinations) will be moved to Rel-16 band specifications, but continue to be release independent.
  - In case Option 5 is not completed by September ASN.1 drop, it will be part of the late drop
- The late Rel-15 ASN.1 drop is to be strictly backwards compatible
- No assumptions are made in this proposal on UE capabilities wrt different NR architecture options

From RAN chairman's report after RAN#79:
IoT – interim conclusions for Rel-16

- No NR based solution will be studied or specified for the LPWA use cases
- LPWA use cases will continue to be addressed by evolving LTE-M(eMTC) and NB-IoT
- Potential enhancements to the already supported coexistence between NR and LTE-M(eMTC)/NB-IoT in Rel-15 may be studied and enhancements standardized if useful and not adversely affecting legacy UEs
- RAN aspects needed for adding connection of LTE-M(eMTC)/NB-IoT to 5G core will be discussed based on SA2 study outcome
- Discussion on other aspects of Rel-16 IoT will continue until June 2018

3GPP Specification series

Go to spec numbering scheme page

Click on spec number for details

spec number	title	notes
TS 38.101	NR; User Equipment (UE) radio transmission and reception	SPECIFICATION WITHDRAWN
TS 38.101-1	NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone	
TS 38.101-2	NR; User Equipment (UE) radio transmission and reception; Part 2: Range 2 Standalone	
TS 38.101-3	NR; User Equipment (UE) radio transmission and reception; Part 3: Range 1 and Range 2 Interworking operation with other radios	
TS 38.101-4	NR; User Equipment (UE) radio transmission and reception; Part 4: Performance requirements	
TS 38.104	NR; Base Station (BS) radio transmission and reception	
TS 38.113	NR; Base Station (BS) ElectroMagnetic Compatibility (EMC)	
TS 38.124	NR; Electromagnetic compatibility (EMC) requirements for mobile terminals and ancillary equipment	
TS 38.133	NR; Requirements for support of radio resource management	
TS 38.141	NR; Base Station (BS) conformance testing	SPECIFICATION WITHDRAWN
TS 38.141-1	NR; Base Station (BS) conformance testing Part 1: Conducted conformance testing	
TS 38.141-2	NR; Base Station (BS) conformance testing Part 2: Radiated conformance testing	
TS 38.201	NR; Physical layer; General description	
TS 38.202	NR; Services provided by the physical layer	
TS 38.211	NR; Physical channels and modulation	
TS 38.212	NR; Multiplexing and channel coding	
TS 38.213	NR; Physical layer procedures for control	
TS 38.214	NR; Physical layer procedures for data	
TS 38.215	NR; Physical layer measurements	
TS 38.300	NR; Overall description; Stage-2	

Full list here: http://www.3gpp.org/DynaReport/38-series.htm

IMT2020 submission format

- Submission 1
  - SRIT
    - Component RIT: NR (TBD incl. NB-IoT, eMTC)
    - Component RIT: EUTRA/LTE (incl. standalone LTE, NB-IoT, eMTC, and LTE-NR DC)
    - full 38 and 36 series, and subset of 37 series (excluding operation in unlicensed spectrum, details TBD)
  - For each component RIT, evaluation shall be performed for all IMT2020 requirements and test environments, and IMT2020 compliance demonstrated against as many IMT2020 requirements and test environments as possible
- Submission 2
  - In addition to above, submit an NR RIT on it's own
  - The plan is to leverage the NR RIT as in submission 1; exact proposal TBD by final submission
- Naming
  - Name : 5G
  - Footnote: Developed by 3GPP as 5G, Release 15 and beyond
- Self-evaluation
  - Detailed plan for 3GPP's self-evaluation agreed in RP-172101

Way forward

- R15 SA spec for 5G NR and NG core stand alone expected to be approved this week
  - Plenaries in La Jolla, US
- R16 study and work item packages expected to be agreed this week
- Submission of 5G candidate technologies to ITU mid 2019
- First 5G NR CPE terminal showcased at MWC 2018
- 5G NR handsets expected 2019

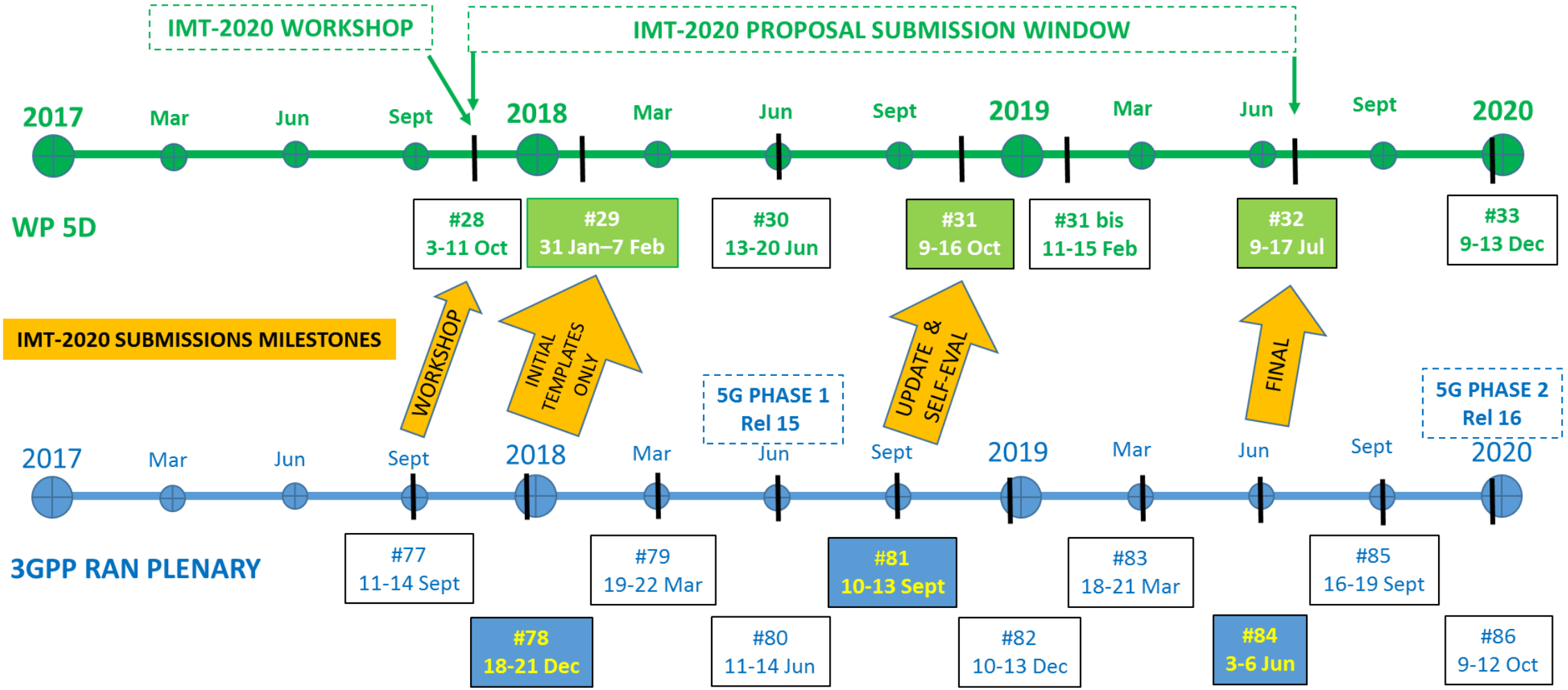
Backup

What is 5G? Radio Design (NR)

A new set of technologies for a generation leap in capabilities

	3G	4G	5G
Downlink waveform	CDMA	OFDM	OFDM, SCFDMA
Uplink waveform	CDMA	SCFDMA	OFDMA, SCFDMA
Channel coding	Turbo	Turbo	LDPC (data) / Polar (L1 contr.)
Beamforming	No	Only data	Full support
Spectrum	0.8 – 2.1 GHz	0.4 – 6 GHz	0.4 – 90 GHz
Bandwidth	5 MHz	1.4 – 20 MHz	Up to 100 MHz (400MHz for >6GHz)
Network slicing	No	No	Yes
QoS	Bearer based	Bearer based	Flow based
Small packet support	No	No	Connectionless
In-built cloud support	No	No	Yes

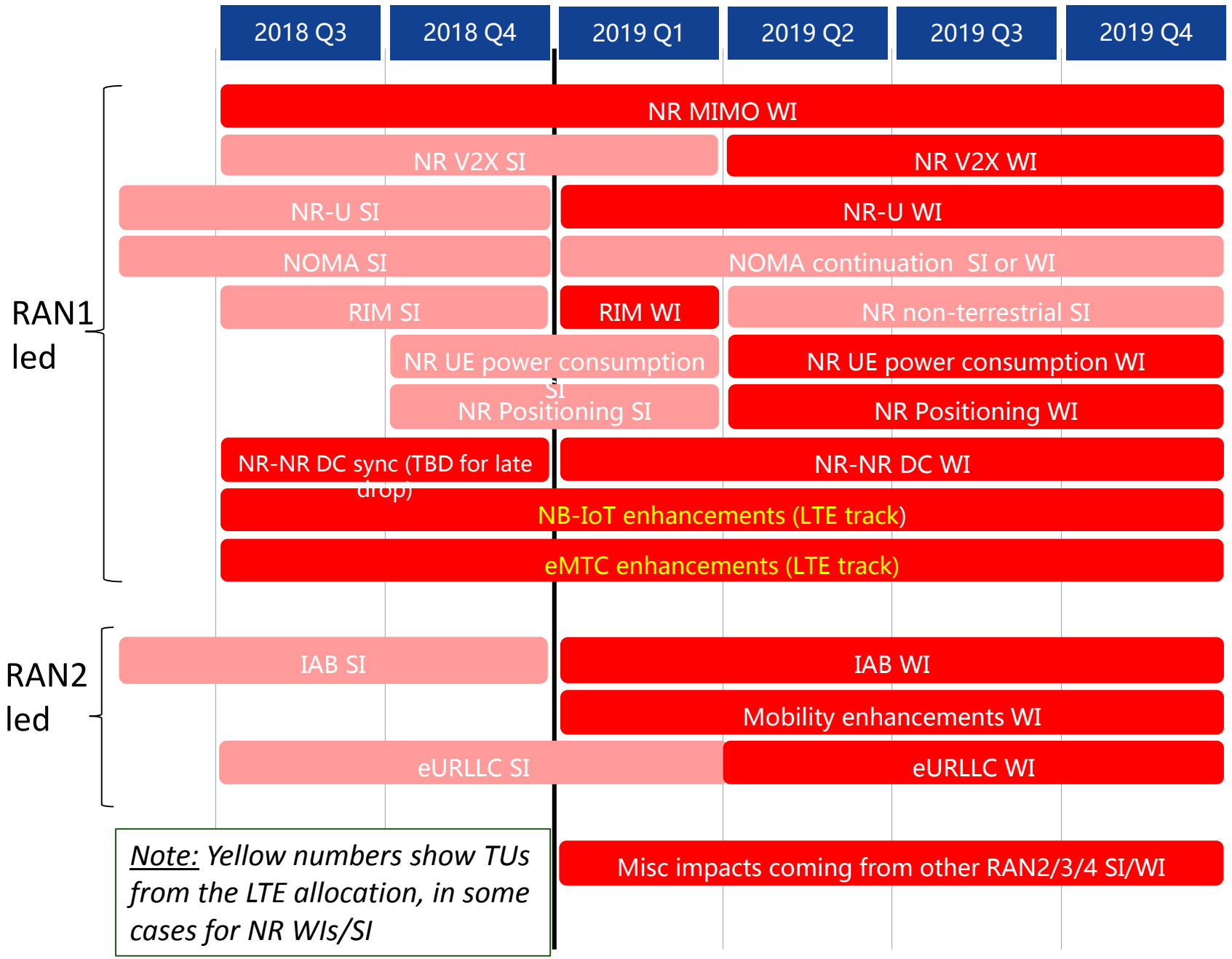
IMT2020 submission - timeplan



IMT2020 submission - timeplan

Submission Milestone Name	3GPP Meeting	ITU-R Meeting	General Submission Content	Submission Templates (Release Basis)	Self- Evaluation (Release Basis)
Workshop	RAN # 77 Sept 2017	WP 5D #28 Oct 2017	Overview	-	-
Initial Templates Only	RAN # 78 Dec 2017	WP 5D # 29 Feb 2018	Description Templates	Description Templates 5.2.3 (R15)	-
Update & Self-Eval	RAN # 81 Sept 2018	WP 5D # 31 Oct 2018	Description Templates Compliance Templates Self-Evaluation	Description Templates 5.2.3 (R15) Compliance Templates 5.2.4 (R15)	Self-Evaluation (R15)
Final	RAN # 84 June 2019	WP 5D # 32 July 2019	Description Templates Compliance Templates Self-Evaluation	Description Templates 5.2.3 (R15+R16) Compliance Templates 5.2.4 (R15+R16)	Self-Evaluation (R15+R16)

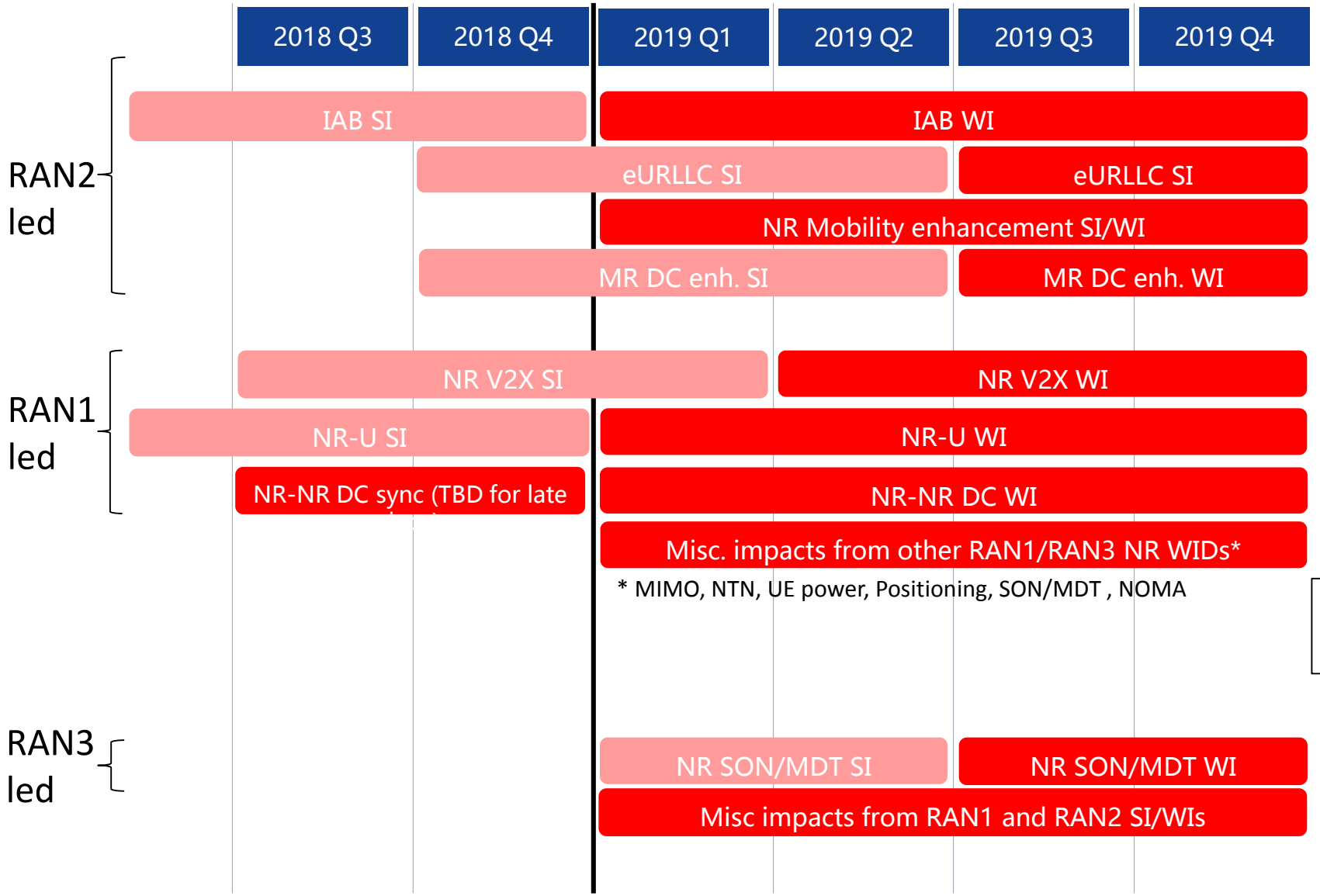
R16 discussion: RAN1



2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019 Q3	2019 Q4
NR:11 LTE: 5	NR:32 LTE:14	NR:18 LTE: 9	NR:40 LTE:19	NR:21 LTE:10	NR:42 LTE:20
1	5	2	6	3	6
2	4	2	6	3	6
2.5	5	3	6	4	8
2.5	5	1	2	1	2
1	2	2	2	1	2
0	3	1	4	1	2
0	2	2	3	2	4
0	0	1	2	1	2
2	5	3	7	4	8
2	5	3	6	3	6
1	2	1	2	1	2
0	0	1	2	1	2
1	4	2	4	2	4
0	0	1	2	1	2

RAN1 TUs

R16 discussion: RAN2 and RAN3



2018 Q3	2018 Q4	2019 Q1	2019 Q2	2019 Q3	2019 Q4
NR:2 LTE:0	NR:14 LTE:14	NR:9 LTE:9	NR:29 LTE:19	NR:16 LTE:10	NR:36 LTE:20
1	4	2	6	3	6
0	2	1	4	3	6
0	0	1	4	2	4
0	2	1	4	2	4
0	3	1	4	2	6
1	2	1	4	2	6
0*	0*	1	2	1	2
0	1,1	1,2	1, 4	1, 3	2, 6

RAN2 TUs

Note: Yellow numbers show TUs from the LTE allocation used for NR WIs/SI

4	10	7.5	17	8	16
0	0	1.5	3	2	4
1	2	2	4	2	4

RAN3 TUs

Table 4.2-1: Supported transmission numerologies.

μ	$\Delta f = 2^{\mu} \cdot 15\,[\text{kHz}]$	**Cyclic prefix**
0	15	Normal
1	30	Normal
2	60	Normal, Extended
3	120	Normal
4	240	Normal
5	480	Normal

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Modulation

- π/2-BPSK
- BPSK
- QPSK
- 16 QAM
- 64 QAM
- 256 QAM

Physical channels UL

- The following uplink physical channels are defined:
  - Physical Uplink Shared Channel, PUSCH
  - Physical Uplink Control Channel, PUCCH
  - Physical Random Access Channel, PRACH
- The following uplink physical signals are defined:
  - Demodulation reference signals, DM-RS
  - Phase-tracking reference signals, PT-RS
  - Sounding reference signal, SRS

Physical channels DL

- The following downlink physical channels are defined:
  - Physical Downlink Shared Channel, PDSCH
  - Physical Broadcast Channel, PBCH
  - Physical Downlink Control Channel, PDCCH.
- The following downlink physical signals are defined:
  - Demodulation reference signals, DM-RS
  - Phase-tracking reference signals, PT-RS
  - Channel-state information reference signal, CSI-RS
  - Primary synchronization signal, PSS
  - Secondary synchronization signal, SSS

- UL/DL decoupling
- Spectrum sharing 4G 5G
- Self backhaul

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