3GPP 5G - Release 16 & 17

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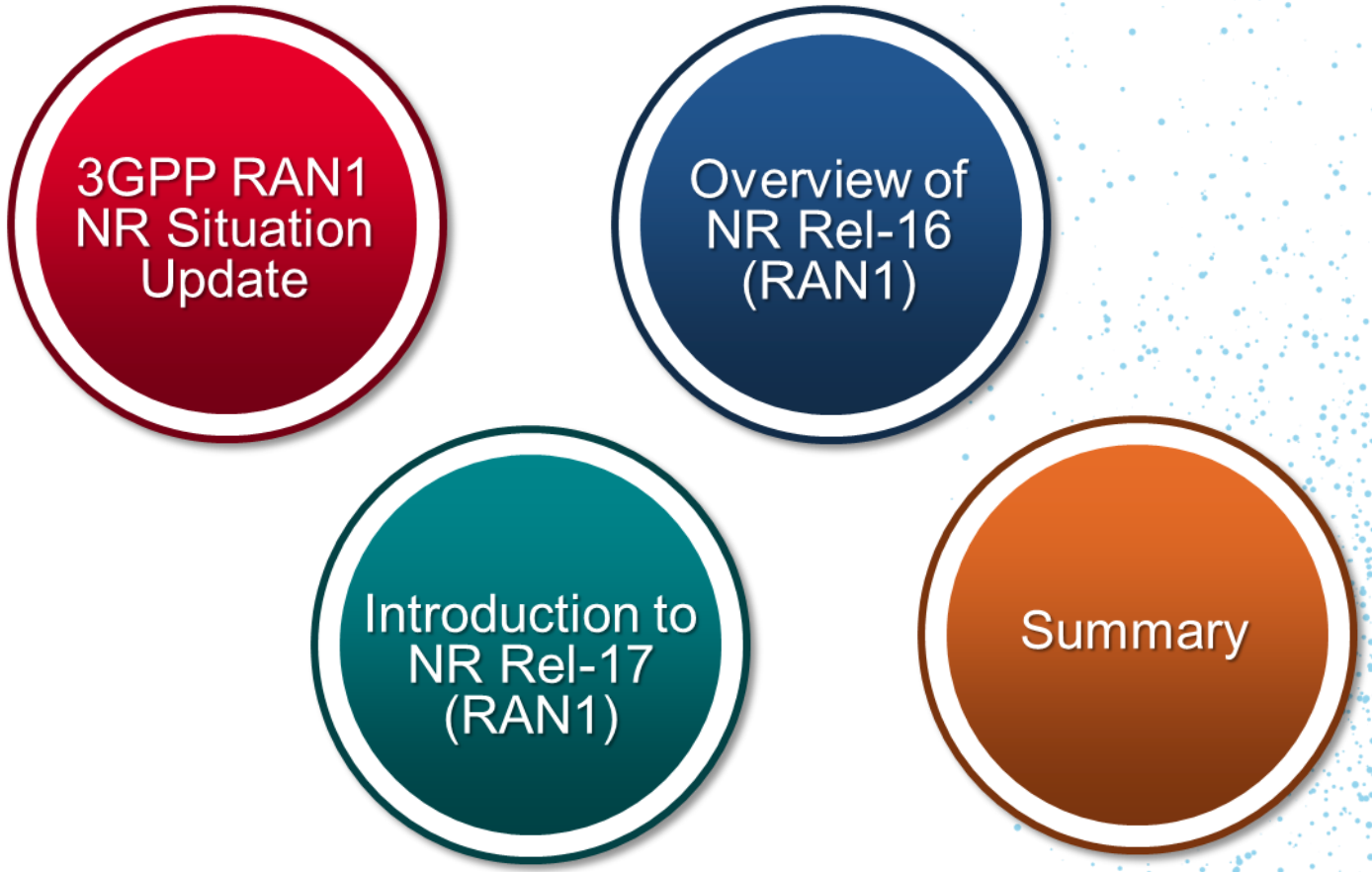
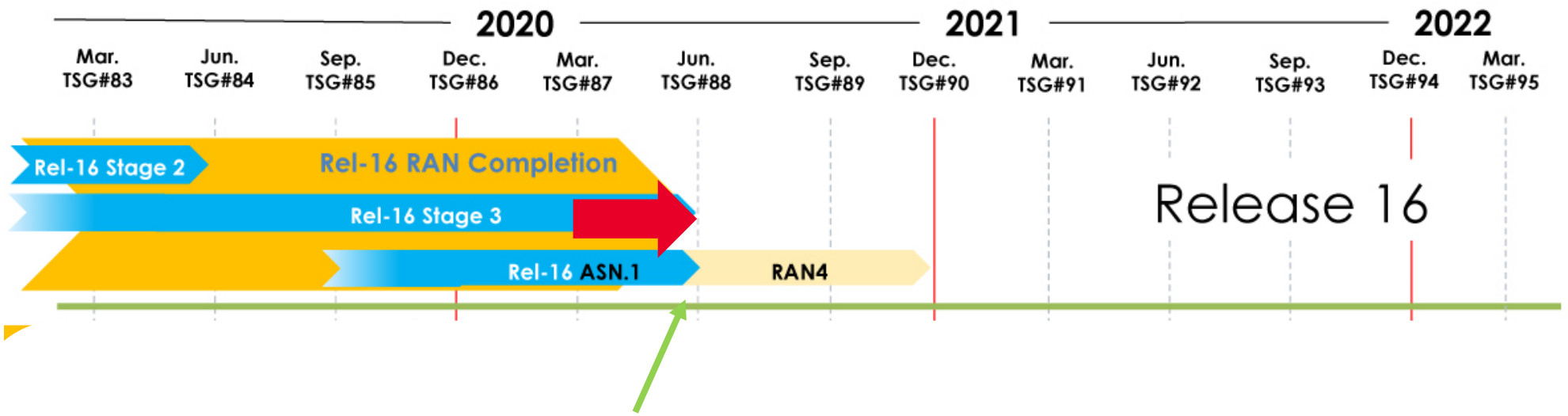
5G NR Standard Evolution: 3GPP RAN1 Update



3GPP RAN1 NR Situation Update

Summary of NR RAN1 Work



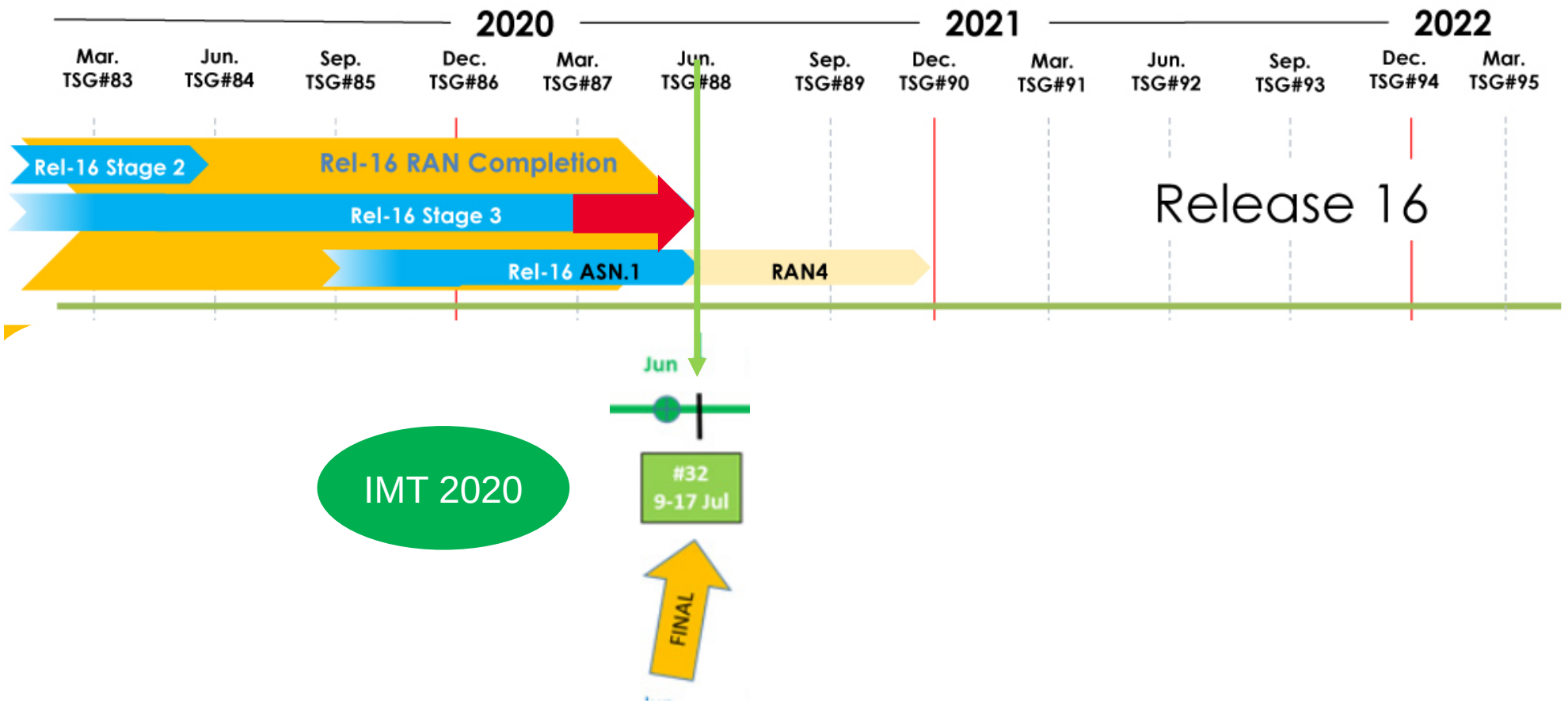
March 23, 2020 Update:

A shift of the Rel-16 timeline was approved at TSG#87 plenary e-meetings:

- Rel-16 Stage 3 freeze now June 2020 (shifted by 3 months)
- Rel-16 ASN.1 and OpenAPI specification freeze will also be complete in June 2020 (stays as planned)

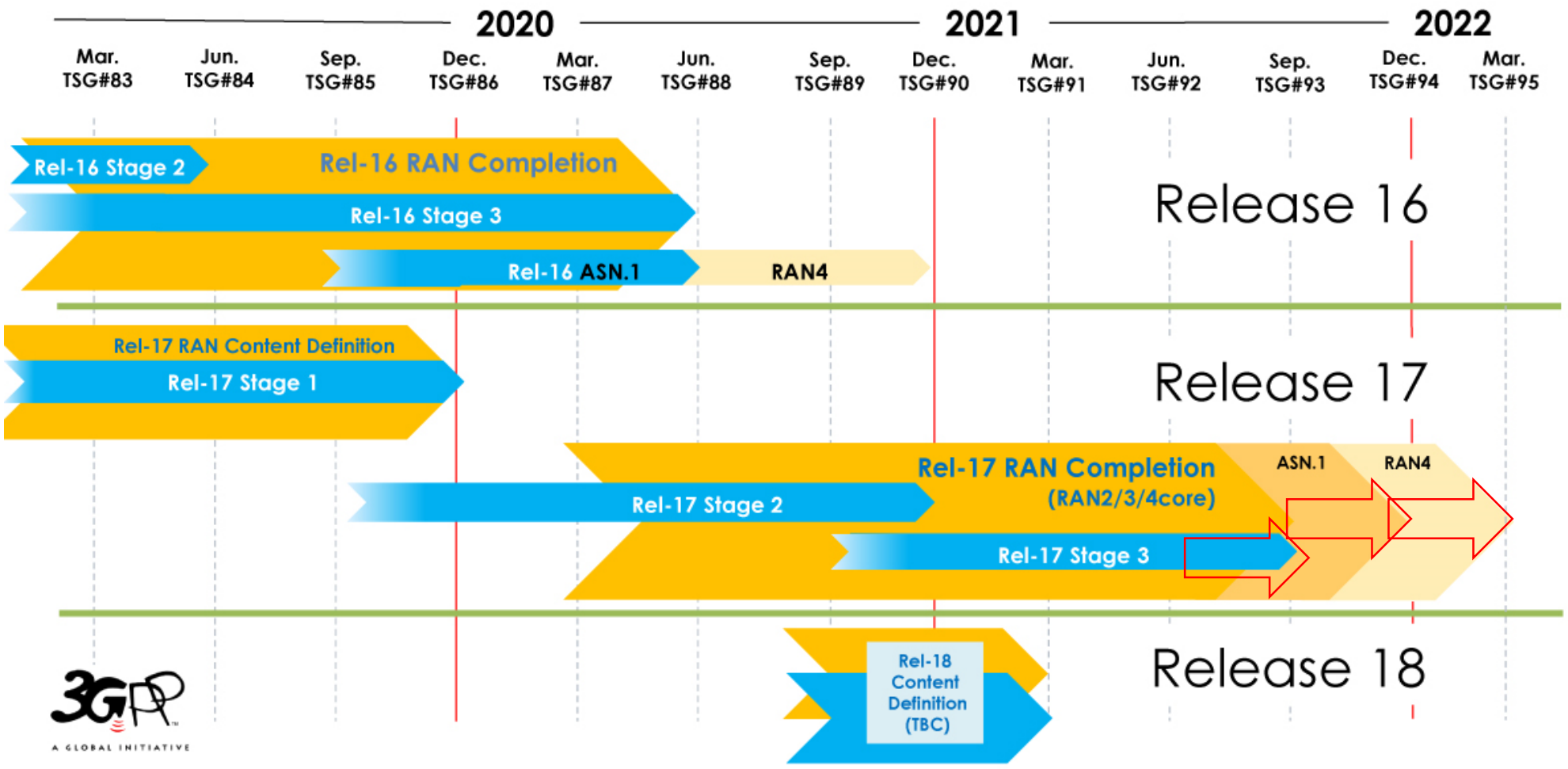
REF: https://www.3gpp.org/release-16

Summary of NR RAN1 Work



REF: https://www.3gpp.org/release-16

Summary of NR RAN1 Work

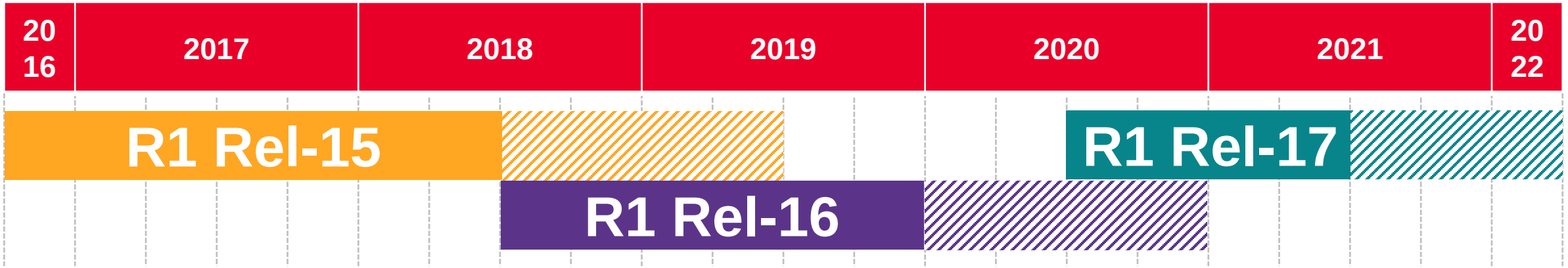


Source: 3GPP TSG SA#87e, 17-20 March 2020, e-meeting document SP-200222

REF: https://www.3gpp.org/release-16

Summary of NR RAN1 Work

3GPP RAN1 NR SITUATION UPDATE



- NR is a **fast evolving standard**
  - Strong industry interest
  - Continuously adapting to new requirements and use cases
  - Second NR release (i.e. **Rel-16**) being completed
  - New NR release (i.e. **Rel-17**) already planned

- RAN1 currently working on:
  - Rel-15 maintenance
  - Rel-16 maintenance
  - Initial Rel-17 work
- RAN1 work on Rel-17 **delayed** due to COVID-19

eMBB

Mobile Broadband Access

mMTC

Massive Machine Communication

URLLC

Mission-Critical Machine Communication

Rel-15

- NSA and SA
- eMBB
- URLLC
- Carrier aggregation operation
- Inter-RAT between NR and LTE

Stable

Rel-16

- IAB
- UE power savings
- IIoT
- UE Positioning
- Unlicensed Spectrum
- V2X
- …

Stabilizing

Rel-17

- NR up to 71 GHz
- NTN
- NR-Light
- Enhancements
- …

Started

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Rel-17

- NR up to 71 GHz
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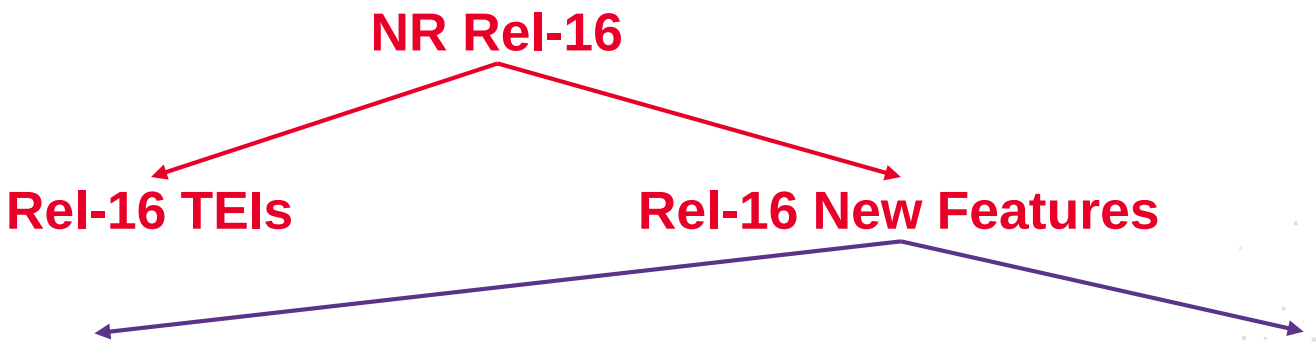
Started

Overview of NR Rel-16 (RAN1)

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)



Capacity and operational efficiency

- MIMO enhancements
- MR-DC (i.e. Multi-RAT Dual Connectivity)
- IAB (i.e. Integrated Access and Backhaul)
- Mobility enhancements
- CLI/RIM (i.e. Cross Link Interference/Remote Interference Management)
- UE power savings
- DSS enhanced

Vertical expansion

- IIoT (i.e. Industrial IoT)
- URLLC (i.e. Ultra Reliable Low Latency)
- 2-step RACH
- NR positioning
- NR unlicensed
- V2X (i.e. Vehicle to Everything)

https://www.3gpp.org/DynaReport/FeatureListFrameSet.htm

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)

NR Rel-16

Rel-16 TEIs

Rel-16 New Features

Capacity and operational efficiency

- MIMO enhancements
- MR-DC (i.e. Multi-RAT Dual Connectivity)
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- ***DSS enhanced***

Vertical expansion

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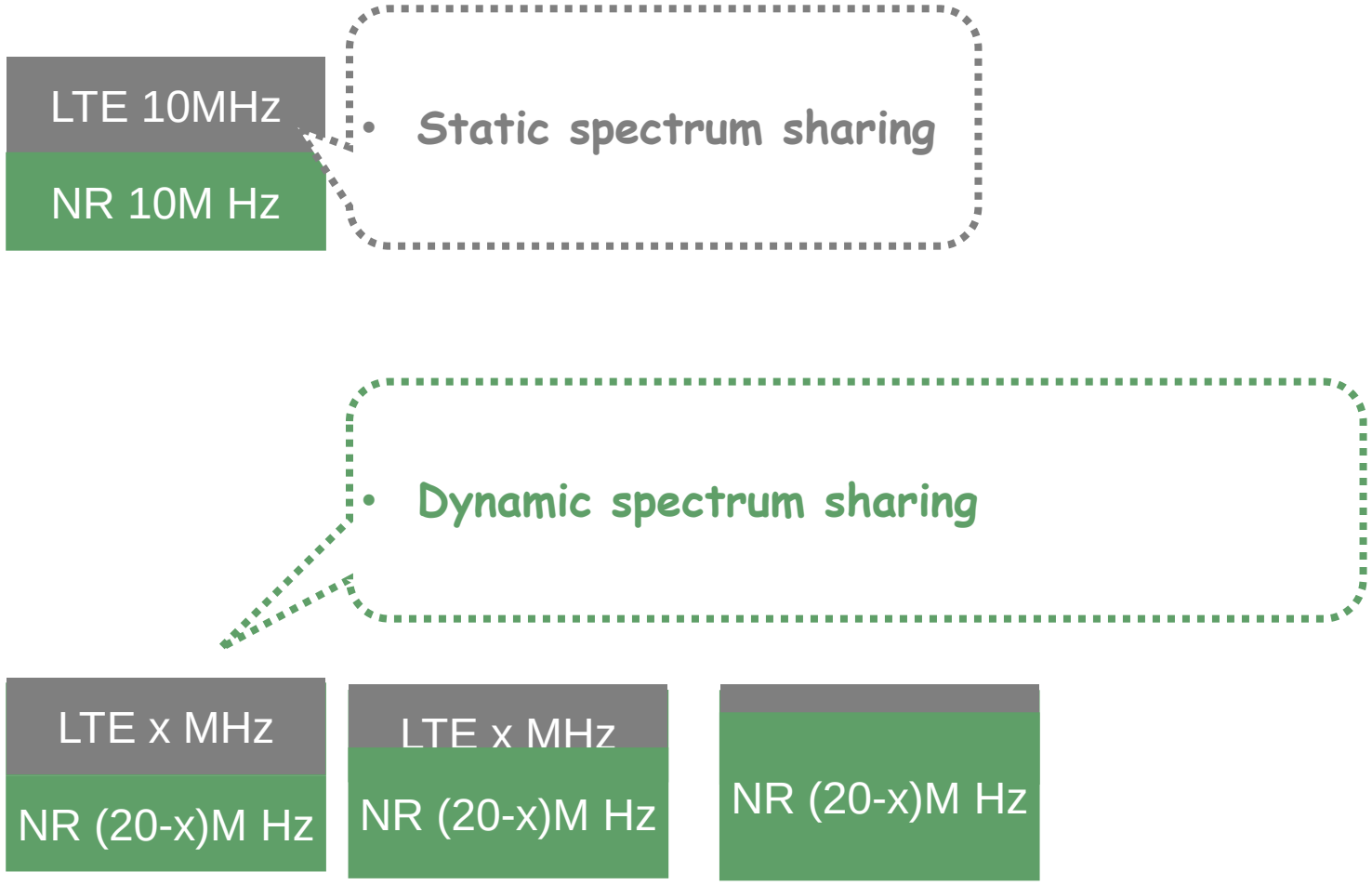
Static spectrum sharing VS Dynamic spectrum sharing

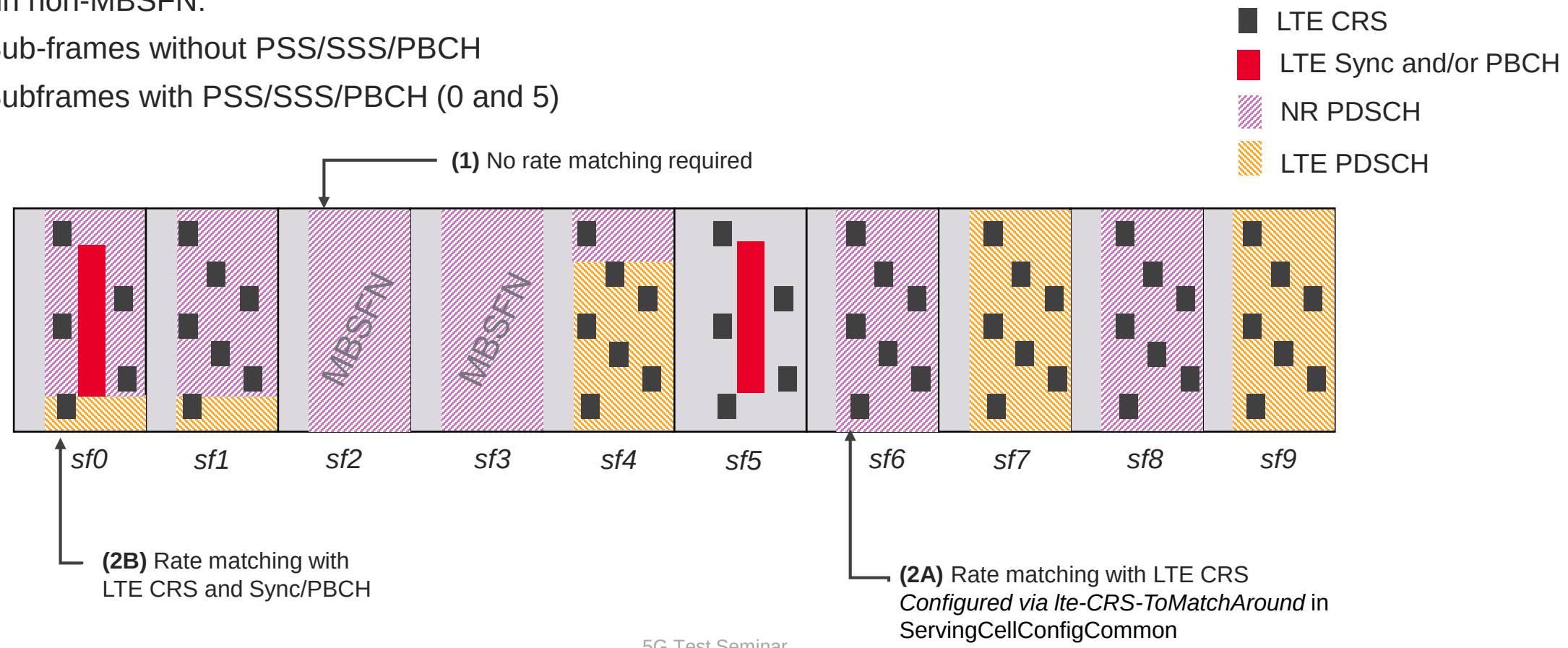


DSS Case

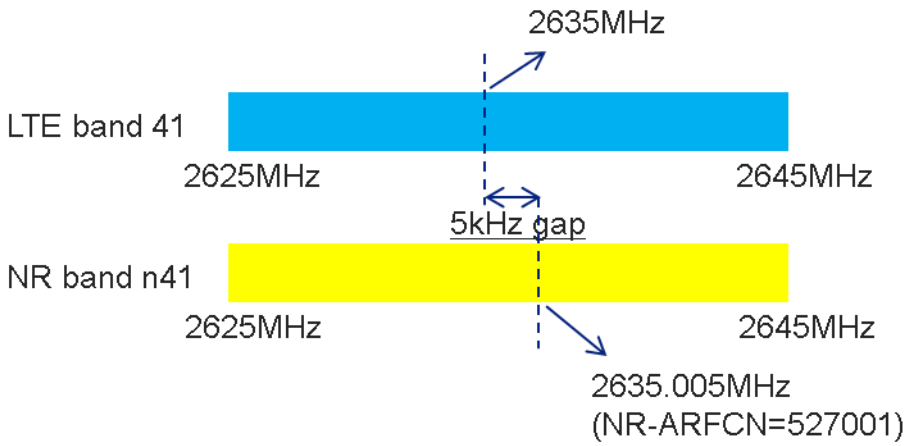
DIFFERENT USE CASES

Three use cases:

1. NR is in MBSFN
2. NR is in non-MBSFN:
   A. Sub-frames without PSS/SSS/PBCH
   B. Subframes with PSS/SSS/PBCH (0 and 5)



DSS between N41B41 / N48B48



Solution#1: Create new NR band with requirements to achieve spectrum sharing (LTE and NR) in 2496 – 2690 MHz.

Solution#2: Addition of new requirements addition into n41 as below;

- Introduce 100kHz channel raster support [RAN4]
- Sync raster specification correction [RAN4]
- Introduce UL 7.5kHz frequency shift [RAN4]

*** above three requirements are at maximum for RAN4. If unnecessary, some of requirements may not be added into n41.**

DSS between N41B41

Band	Name	Mode	ΔF_{Raster} (kHz)	N_{ref} step size	Downlink (MHz) nr-arfcn Low	Middle	High	Bandwidth DL/UL (MHz)	Uplink (MHz) nr-arfcn Low	Middle	High	Duplex spacing (MHz)	Geographical area	3GPP release
n41	TD 2600+	TDD			2496	2593	2690	194					Global	15.0
			15	3	499200	518601	537999							
			30	6	499200	518598	537996							
n90	TD 2600+	TDD			2496	2593	2690	194					Global	16.0
			15	3	499200	518601	537999							
			30	6	499200	518598	537996							
			100	20	499200	518600	538000							

https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_87e/Docs/RP-200234.zip
https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_84/Docs/RP-191588.zip

800078	**29 dBm UE Power Class for LTE band 41 and NR Band n41**	**LTE_NR_B41_Bn41_PC29dBm**	**R4**	RP-201134	**Sprint**
800178	**Core part: 29 dBm UE Power Class for LTE band 41 and NR Band n41**	LTE_NR_B41_Bn41_PC29dBm-Core	R4	RP-201134	Sprint

860060	**LTE/NR spectrum sharing in band 48/n48 frequency range**	**NR_n48_LTE_48_coex**	**R4**	RP-201858	**Apple**
860160	**Core part: LTE/NR spectrum sharing in band 48/n48 frequency range**	NR_n48_LTE_48_coex	R4	RP-201858	Apple

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)

NR Rel-16

Rel-16 TEIs

Rel-16 New Features

Capacity and operational efficiency

- MIMO enhancements
- MR-DC (i.e. Multi-RAT Dual Connectivity)
- IAB (i.e. Integrated Access and Backhaul)
- Mobility enhancements
- CLI/RIM (i.e. Cross Link Interference/Remote Interference Management)
- UE power savings
- DSS enhanced

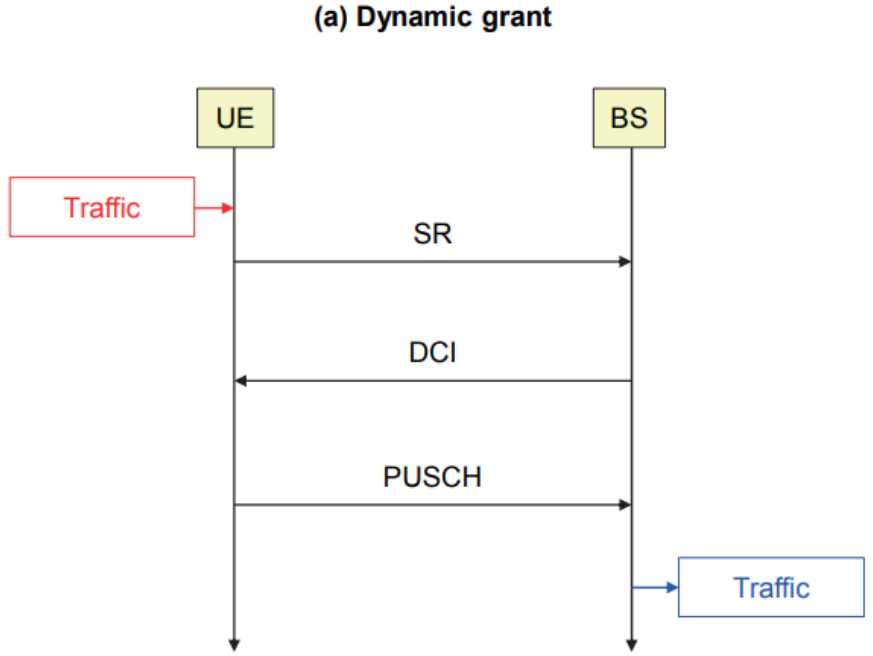
Vertical expansion

- IIoT (i.e. Industrial IoT)
- ***URLLC (i.e. Ultra Reliable Low Latency)***
- 2-step RACH
- NR positioning
- NR unlicensed
- V2X (i.e. Vehicle to Everything)

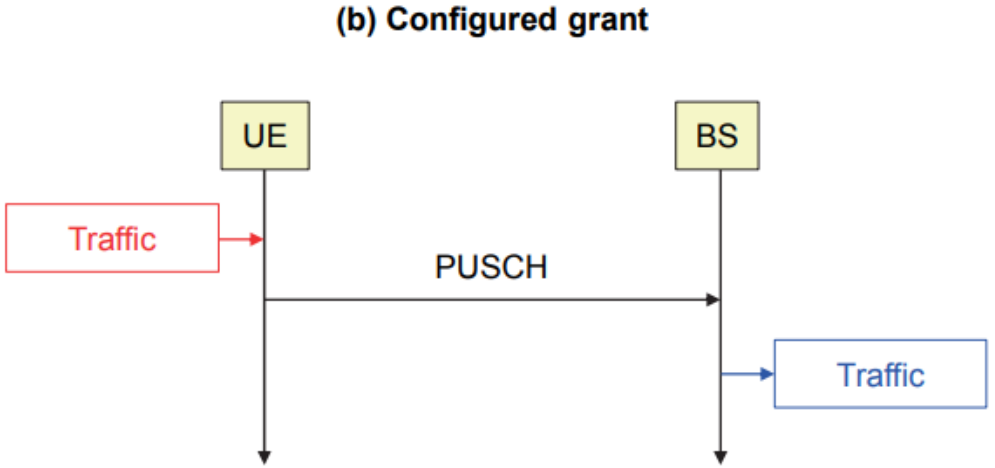
https://www.3gpp.org/DynaReport/FeatureListFrameSet.htm

URLLC Enhancement

- **Release 15** enabled use case improvements
  - Such as AR/VR (Entertainment industry)
- **New Release 16** use cases with higher requirements
  - Factory automation
  - Transport Industry, including the remote driving use case
  - Electrical Power Distribution



- **Rel-15:** basic URLLC functionality
  - **Low latency**: ***larger subcarrier spacing***, ***mini-slots***, ***configured grant***, …



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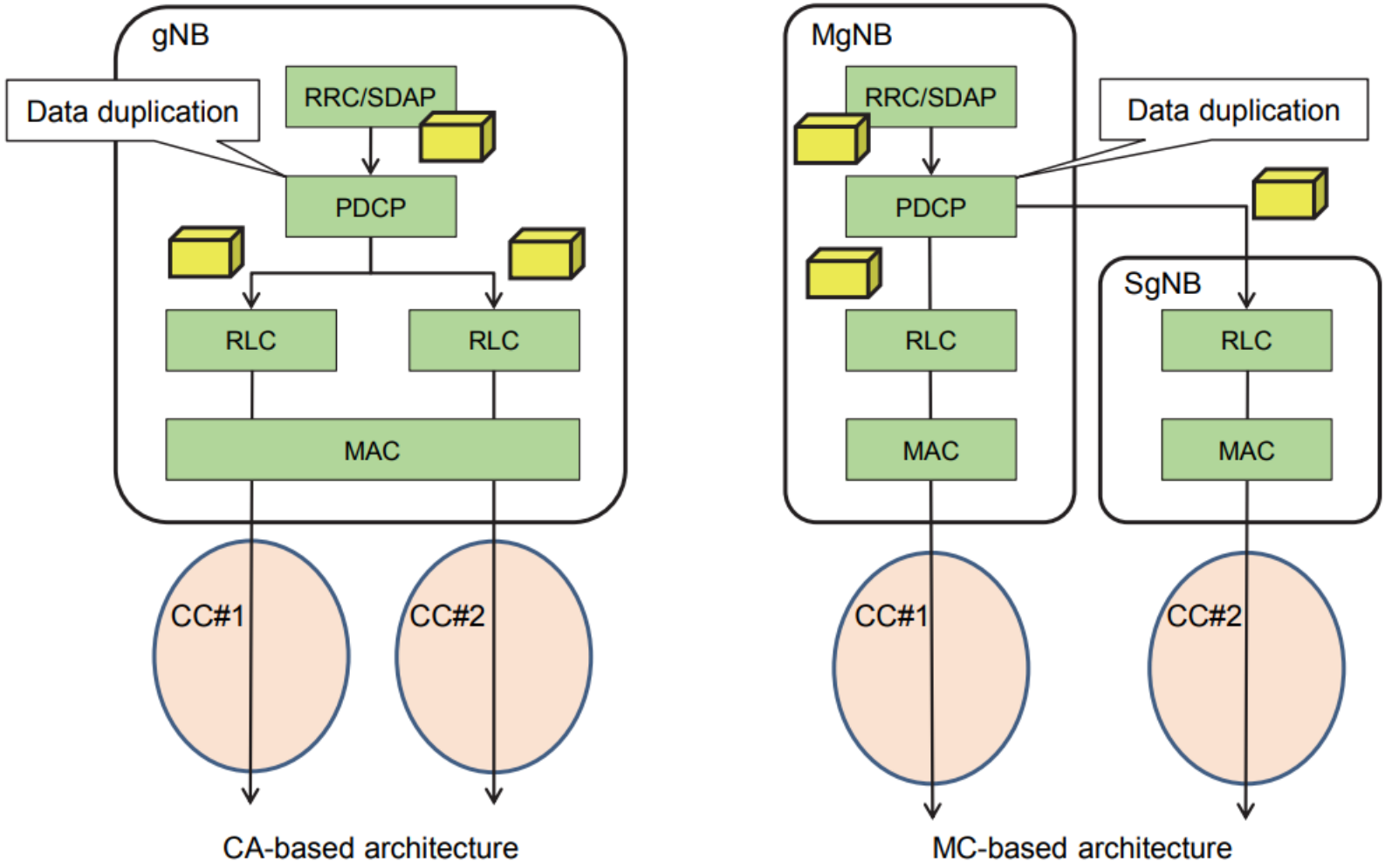
URLLC Enhancement

- **Rel-15:** basic URLLC functionality
  - **Higher reliability**: ***PDCP duplication***, ***low SE MCS/CQI tables***



URLLC Enhancement

- **Rel-15:** basic URLLC functionality
  - **Higher reliability**: ***PDCP duplication***, ***low SE MCS/CQI tables***

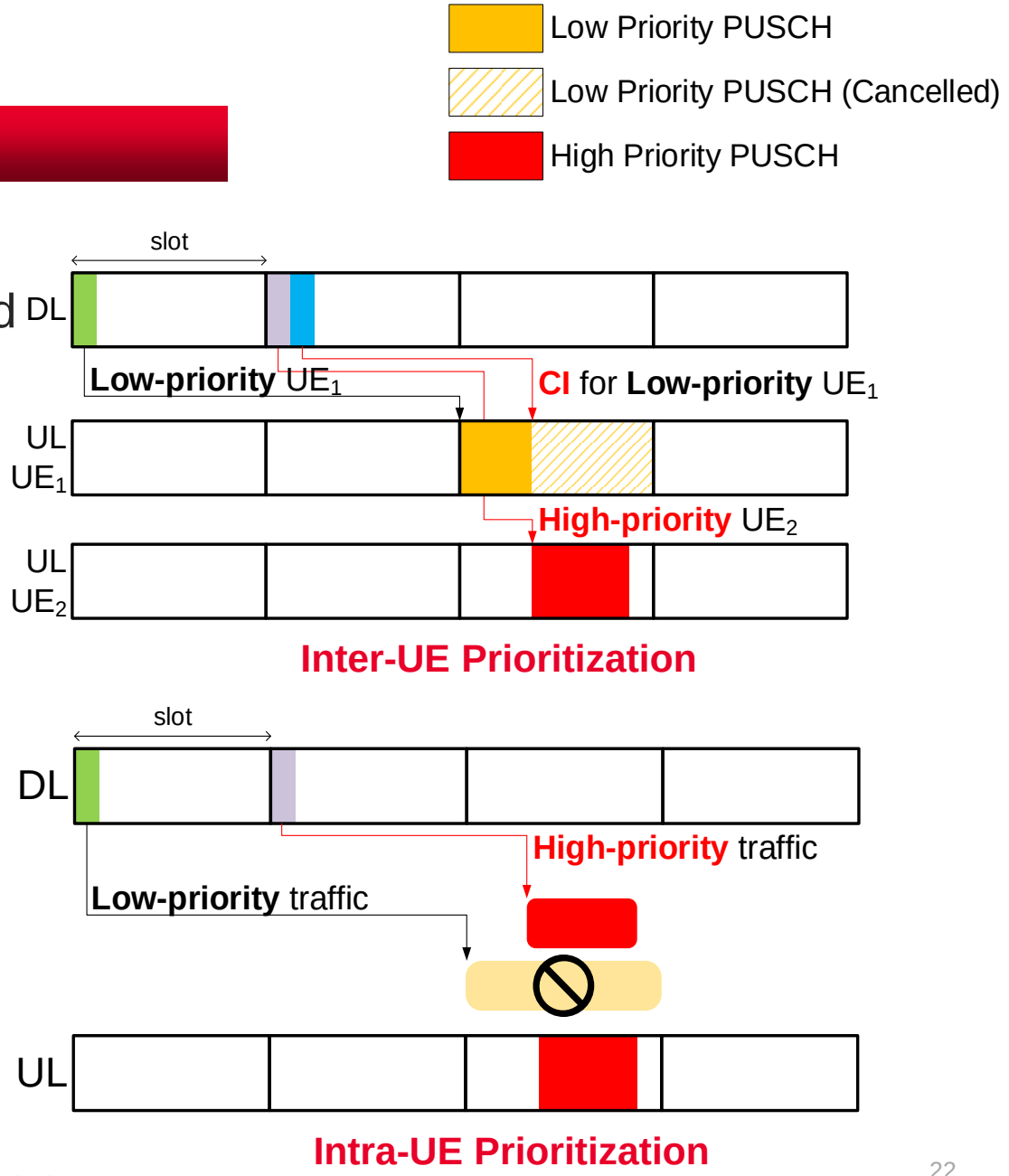
Table 5.1.3.1-3: MCS index table 3 for PDSCH

MCS Index I_{MCS}	Modulation Order Q_m	Target code Rate R x [1024]	Spectral efficiency
0	2	30	0.0586
1	2	40	0.0781
2	2	50	0.0977
3	2	64	0.1250
4	2	78	0.1523
5	2	99	0.1934
6	2	120	0.2344
7	2	157	0.3066
8	2	193	0.3770
9	2	251	0.4902
10	2	308	0.6016
11	2	379	0.7402
12	2	449	0.8770
13	2	526	1.0273
14	2	602	1.1758
15	4	340	1.3281
16	4	378	1.4766
17	4	434	1.6953
18	4	490	1.9141
19	4	553	2.1602
20	4	616	2.4063
21	6	438	2.5664
22	6	466	2.7305
23	6	517	3.0293
24	6	567	3.3223
25	6	616	3.6094
26	6	666	3.9023
27	6	719	4.2129
28	6	772	4.5234
29	2	reserved	
30	4	reserved	
31	6	reserved	

URLLC Enhancements

OVERVIEW OF NR REL-16 (RAN1)

- To achieve higher reliability up to ***1E-6*** and short latency in the order of ***0.5 to 1ms***, have been identified as important areas for NR.
  - TR 38.824 and TR 38.825.
- **UE Tx prioritization/multiplexing**
  - **Inter-UE** Tx prioritization and multiplexing
  - **Intra-UE** Tx prioritization and multiplexing
- **DCI format 2_4** is introduced for notifying the PRB(s) and OFDM symbol(s) where UE ***cancels*** the corresponding UL transmission from the UE >> a ***PUSCH*** transmission or an ***SRS*** transmission on the serving cell.



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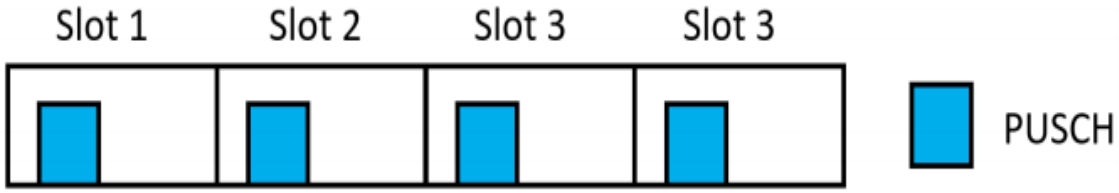
https://www.3gpp.org/DynaReport/FeatureOrStudyItemFile-830074.htm

URLLC Enhancements

OVERVIEW OF NR REL-16 (RAN1)

- **PUSCH enhancements** :
  - **PUSCH repetition type A :** PUSCH repetition type A can improve the spectral efficiency.
  - **PUSCH repetition type B** : is mainly beneficial for achieving low latency
    - one dynamic UL grant or one configured grant schedules two or more PUSCH repetitions that can be in one slot, or across slot boundary in consecutive available slots



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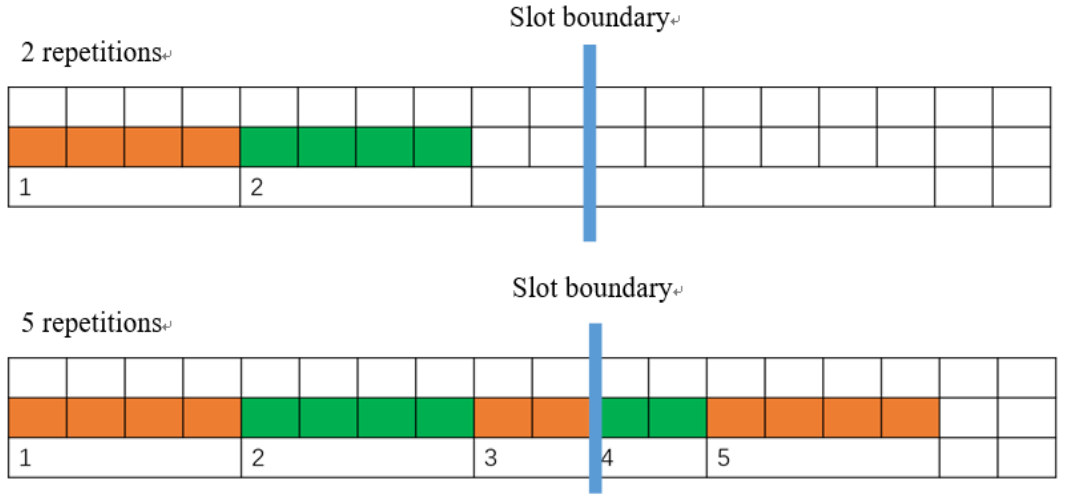

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URLLC Enhancements

OVERVIEW OF NR REL-16 (RAN1)

- **Specification of PDCCH/UCI enhancements**
  - ***Rel-16 span-based PDCCH monitoring capability*** is introduced mainly for achieving low latency
  - A UE can indicate a capability to monitor PDCCH according to one or more of the combinations (X, Y) = (2, 2), (4, 3), and (7, 3) per SCS configuration of μ=0 and μ=1.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Combination (4, 3)	Span 1					Span 2					Span 3			

- **Enhanced power control :**
  - including dynamic change of power control parameters (e.g. P0 and alpha without SRI configured) and enhanced TPC (e.g. increased TPC range and finer granularity).. (see section 7.2.2 in TR 38.824)

https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_84/Docs/RP-191584.zip

https://www.3gpp.org/DynaReport/FeatureOrStudyItemFile-830074.htm

830098	**Enhancement of URLLC support in the 5G Core network**	**5G_URLLC**	**S2**	**SP-181122**	**Hui Ni, Huawei**
790008	**Study on enhancement of URLLC supporting in 5GC**	FS_5G_URLLC	S2	SP-180118	Hui Ni, Huawei
810036	**Study on the security of URLLC for 5GS**	FS_5G_URLLC_SEC	S3	SP-180910	Rong Wu, Huawei Technologies
820019	**Stage 2 of 5G_URLLC**	5G_URLLC	S2	SP-181122	Hui Ni, Huawei
840026	**Security of URLLC for 5GS**	5G_URLLC_SEC	S3	SP-190351	Rong Wu, Huawei Technologies
840005	**CT Aspects of 5G_URLLC**	**5G_URLLC**	**ct**	**CP-191063**	**Qi Caixia, Huawei**
840060	CT3 Aspects of 5G_URLLC	5G_URLLC	C3	CP-191063	Qi Caixia, Huawei
840061	CT4 Aspects of 5G_URLLC	5G_URLLC	C4	CP-191063	Qi Caixia, Huawei
780030	*Stopped - Study on EPC support for Mobility with Low Latency Communication*	FS_LLC_Mob	S2	SP-171069	Chris PUDNEY
790009	*Stopped - Study on enht of systems using EPS for UR and Availability using commodity equipment*	FS_EPS_URACE	S2	SP-180119	Chris Pudney

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)

NR Rel-16

Rel-16 TEIs

- MIMO enhancements
- MR-DC (i.e. Multi-RAT Dual Connectivity)
- IAB (i.e. Integrated Access and Backhaul)
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- UE power savings
- DSS enhanced

Rel-16 New Features

Capacity and operational efficiency

Vertical expansion

- IIoT (i.e. Industrial IoT)
- URLLC (i.e. Ultra Reliable Low Latency)
- ***2-step RACH***
- NR positioning
- ***NR unlicensed***
- V2X (i.e. Vehicle to Everything)

https://www.3gpp.org/DynaReport/FeatureListFrameSet.htm

Unlicensed Spectrum

OVERVIEW OF NR REL-16 (RAN1)

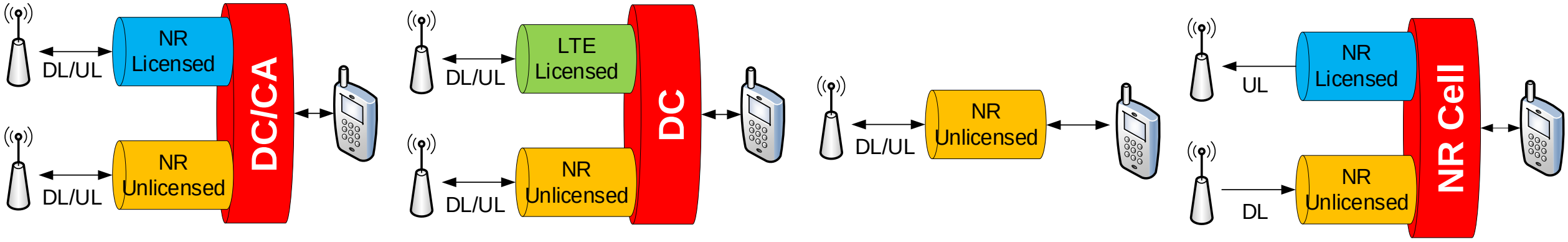
- **Spectrum**:
  - Boosting capacity and improving data connectivity
  - the 5GHz unlicensed band and the 6GHz band under discussion for unlicensed use (e.g., **US 5925 – 7125 MHz, or European 5925 – 6425 MHz**)
  - possibly in the FR2 regime or above **52.6 GHz**, could be considered at later releases.

NR operating band	Uplink (UL) *operating band* BS receive / UE transmit F_{UL_low} – F_{UL_high}	Downlink (DL) *operating band* BS transmit / UE receive F_{DL_low} – F_{DL_high}	Duplex Mode
n46	5150 MHz – 5925 MHz	5150 MHz – 5925 MHz	TDD[13]
n96[14]	5925 MHz – 7125 MHz	5925 MHz – 7125 MHz	TDD[13]

Unlicensed Spectrum

OVERVIEW OF NR REL-16 (RAN1)

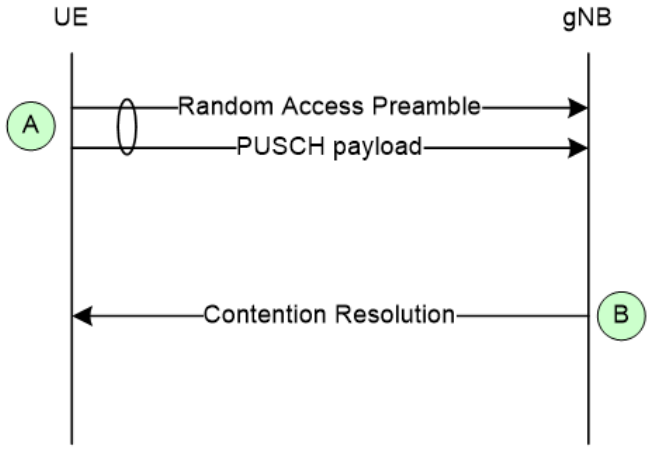
- **Scenarios**
- Scenario A: Carrier aggregation between licensed band NR (PCell) and NR-U (SCell)
- Scenario B: Dual connectivity between licensed band LTE (PCell) and NR-U (PSCell)
- Scenario C: Stand-alone NR-U
- Scenario D: A stand-alone NR cell in unlicensed band and UL in licensed band
- Scenario E: Dual connectivity between licensed band NR and NR-U



Unlicensed Spectrum

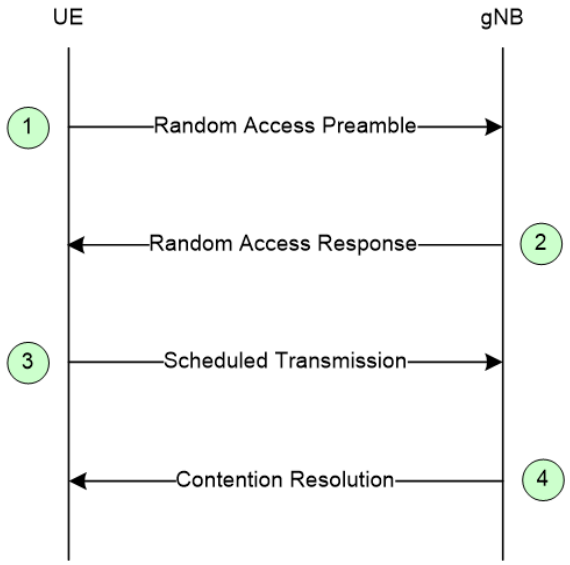
OVERVIEW OF NR REL-16 (RAN1)

- **Physical layer aspects**
  - Wide-band operation (in integer multiples of 20MHz)
  - LBT (**Listen-Before-Talk**) : LBE and FBE (TR 38.889, Section 7.2.1.3.1)
  - Discovery Reference Signal (DRS) : to increase the maximum number of candidate SS/PBCH block positions within the DRS transmission window



(b) 2-step RACH

- 4-step RACH modifications to handle reduced Msg 1/2/3/4 transmission opportunities due to LBT failure (RAN1/RAN2)
- LBT for 2-step RACH and application of PRACH and PUSCH format improvements for NR-U to 2-step RACH.



(a) 4-step RACH

820067	**NR-based access to unlicensed spectrum**	**NR_unlic**	**R1**	**RP-191575**	**Qualcomm**
750045	**Study on NR-based access to unlicensed spectrum**	FS_NR_unlic	R1	RP-181339	Qualcomm
820167	**Core part: NR-based access to unlicensed spectrum**	NR_unlic-Core	R1	RP-190706	Qualcomm
820267	**Perf. part: NR-based access to unlicensed spectrum**	NR_unlic-Perf	R4	RP-190706	Qualcomm

820068	**2-step RACH for NR**	**NR_2step_RACH**	**R1**	**RP-190711**	**ZTE**
820168	**Core part: 2-step RACH for NR**	**NR_2step_RACH-Core**	**R1**	**RP-190711**	**ZTE**
820268	**Perf. part: 2-step RACH for NR**	**NR_2step_RACH-Perf**	**R4**	**RP-190711**	**ZTE**

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)

NR Rel-16

Rel-16 TEIs

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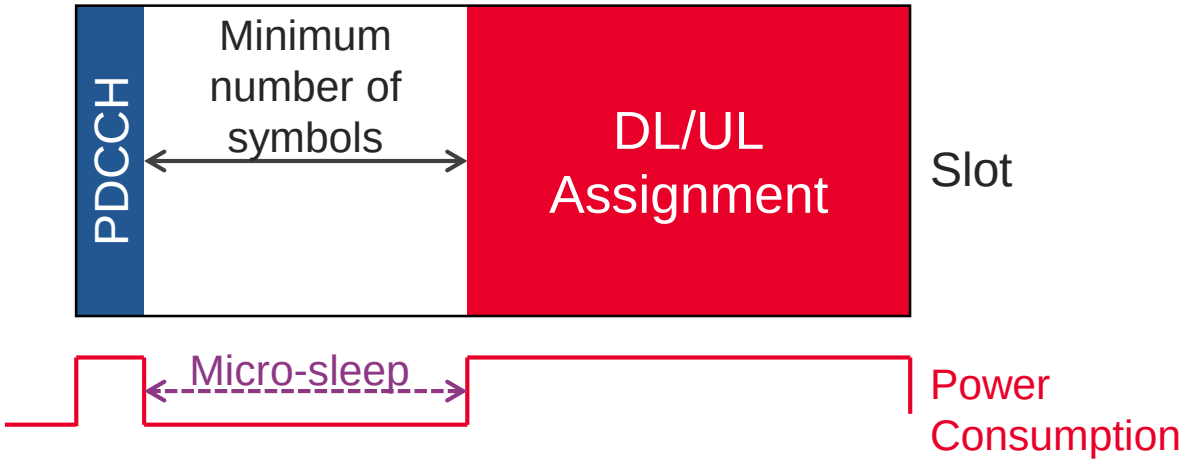
UE Power Saving

OVERVIEW OF NR REL-16 (RAN1)

RP-200494

- **Power saving techniques**
  - ***Time domain***

- **Time Domain Resource Allocation**
  - Guarantee a **minimum number of symbols** between PDCCH and DL/UL assignment
  - Allow UE to **micro-sleep** between reception of PDCCH and corresponding DL/UL



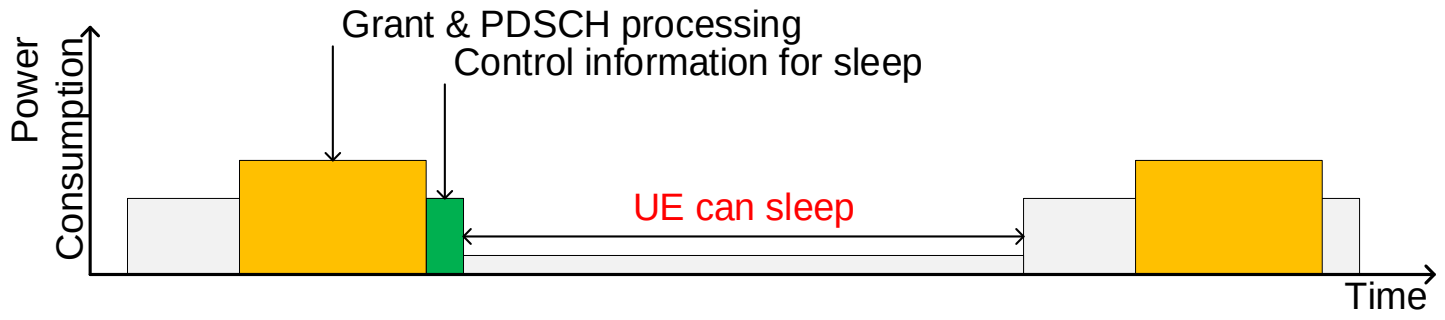
UE Power Saving

OVERVIEW OF NR REL-16 (RAN1)

- **Power saving techniques**
  - Time domain
  - ***RX adaption***

RP-200494

- A new ***DCI format 2_6*** is introduced contains the ***wakeup indication*** as well as ***SCell dormancy indication*** if configured.
  - **Wakeup**
    - UE is indicated to transition from outside Active Time to Active Time
  - **Go to sleep**
    - UE is indicated to transition from Active Time to outside Active Time



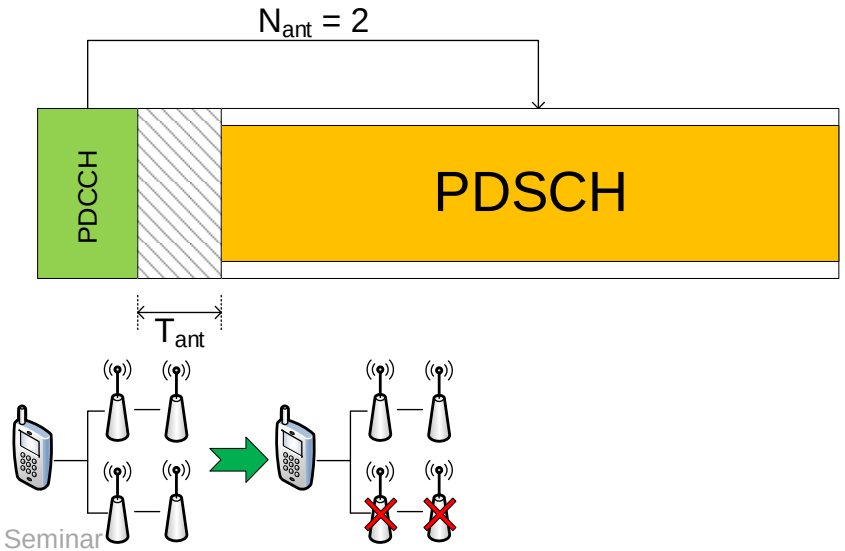
UE Power Saving

OVERVIEW OF NR REL-16 (RAN1)

RP-200494

- **Power saving techniques**
  - Time domain
  - DRX configuration
  - ***Antenna domain***assistance information

- **MIMO Layer Adaptation**
  - be achieved by dynamic switching of BWPs, which the DL maximum number of MIMO layers are configured to be different.
  - Reduce the number of DL MIMO layers
  - Allows the UE to reduce the number of antennas



UE Power Saving

OVERVIEW OF NR REL-16 (RAN1)

- **Power saving techniques**
  - Time domain
  - DRX configuration
  - Antenna domain
  - ***Assistance information from UE***
  - ***Reduced RRM measurements***

- UE can feed back the assistance information of its preference to be released/suspended for gNB to get UE transitioning out of CONNECTED state quickly when there is no further data arrival.

- allows the UE to feedback its preferred configuration, such as c-DRX configuration, aggregated bandwidth, SCell configuration, MIMO configuration, RRC state, minimum scheduling offset values in order for network to assist UE achieving power saving gain.

- Power saving in RRC_IDLE and RRC_INACTIVE can also be achieved by UE relaxing neighbour cells RRM measurements when it meets the criteria determining it is in low mobility and/or not at cell edge.

830075	**UE Power Saving in NR**	**NR_UE_pow_sav**	**R1**	**RP-191607**	**CATT**
800094	**Study on UE power saving in NR**	FS_NR_UE_pow_sav	R1	RP-181463	CATT
830175	**Core part: UE Power Saving in NR**	NR_UE_pow_sav-Core	R1	RP-190727	CATT
830275	**Perf. part: UE Power Saving in NR**	NR_UE_pow_sav-Perf	R4	RP-190727	CATT

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)

NR Rel-16

Rel-16 TEIs

Rel-16 New Features

Capacity and operational efficiency

- MIMO enhancements
- MR-DC (i.e. Multi-RAT Dual Connectivity)
- IAB (i.e. Integrated Access and Backhaul)
- Mobility enhancements
- CLI/RIM (i.e. Cross Link Interference/Remote Interference Management)
- UE power savings
- DSS enhanced

Vertical expansion

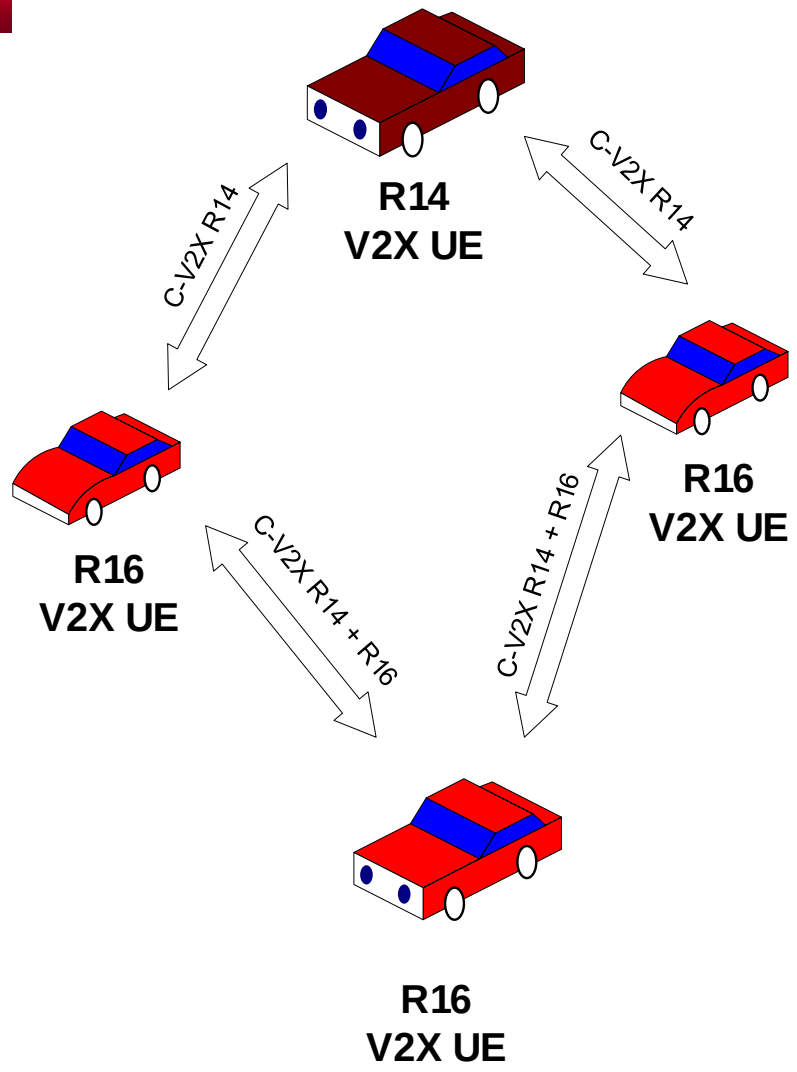
- IIoT (i.e. Industrial IoT)
- URLLC (i.e. Ultra Reliable Low Latency)
- 2-step RACH
- NR positioning
- NR unlicensed
- ***V2X (i.e. Vehicle to Everything)***

https://www.3gpp.org/DynaReport/FeatureListFrameSet.htm

V2X (Sidelink)

OVERVIEW OF NR REL-16 (RAN1)

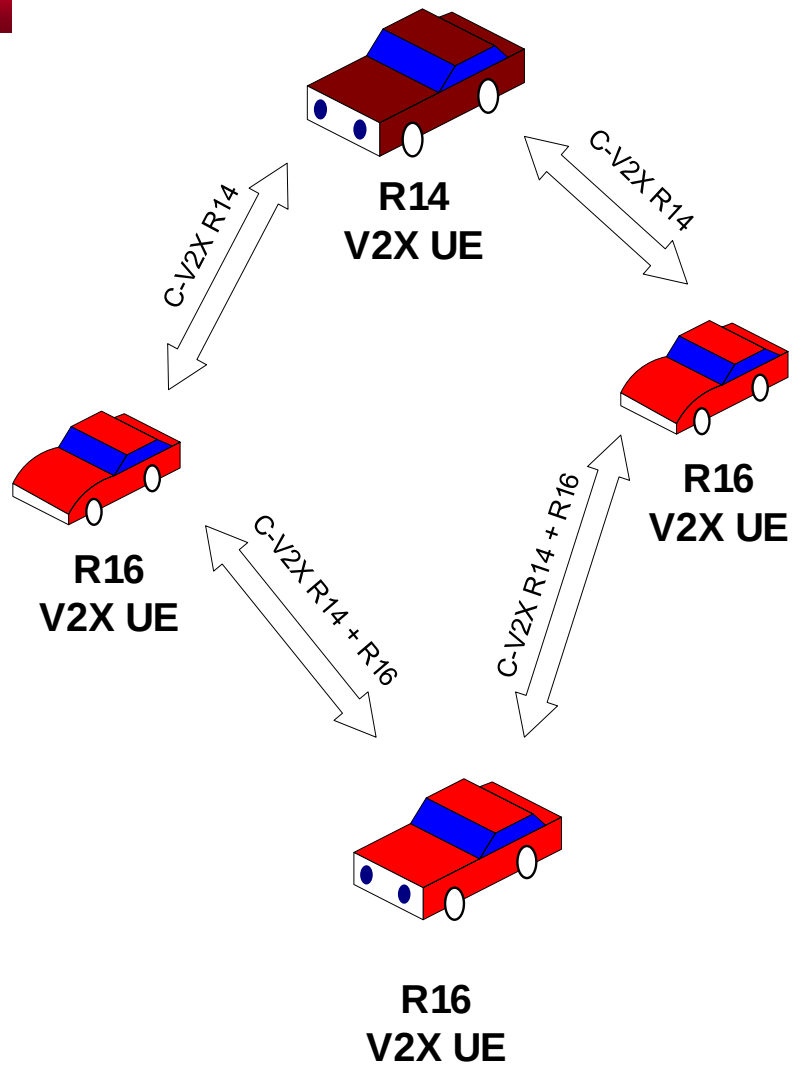
- **Evolution of Cellular V2X**
  - Rel-14 LTE V2X: (3GPP V2X phase 1)
    - Basic road safety support
    - Vehicles (i.e., UEs supporting V2X applications) can exchange their own status information through sidelink, such as position, speed and heading, with other nearby vehicles, infrastructure nodes and/or pedestrians.
  - Rel-15 LTE V2X (3GPP V2X phase 2)
    - Increase data speed and reduce latency
    - Rel-15 introduces a number of new features in sidelink, including: carrier aggregation, high order modulation, latency reduction, and feasibility study on both transmission diversity and short TTI in sidelink.
  - **NR V2X complements LTE V2X** with advanced use cases (3GPP V2X phase 3)
- **Advanced use cases for NR V2X**
  - Increased situational awareness, sensor sharing, coordinated driving and intention sharing, real-time infrastructure updates, …



V2X (Sidelink)

OVERVIEW OF NR REL-16 (RAN1)

- NR V2X or LTE V2X?
  - TR 38.913 : it is not intended for NR V2X to replace the services offered by LTE V2X. Instead, the NR V2X shall complement LTE V2X for advanced V2X services and support interworking with LTE V2X. …
- **NR V2X Features in Rel-16**
  - Sidelink
  - Cross-RAT control (i.e. NR Uu controls LTE PC5)
  - QoS management
  - Compatibility and coexistence with Rel-14/15 LTE V2X



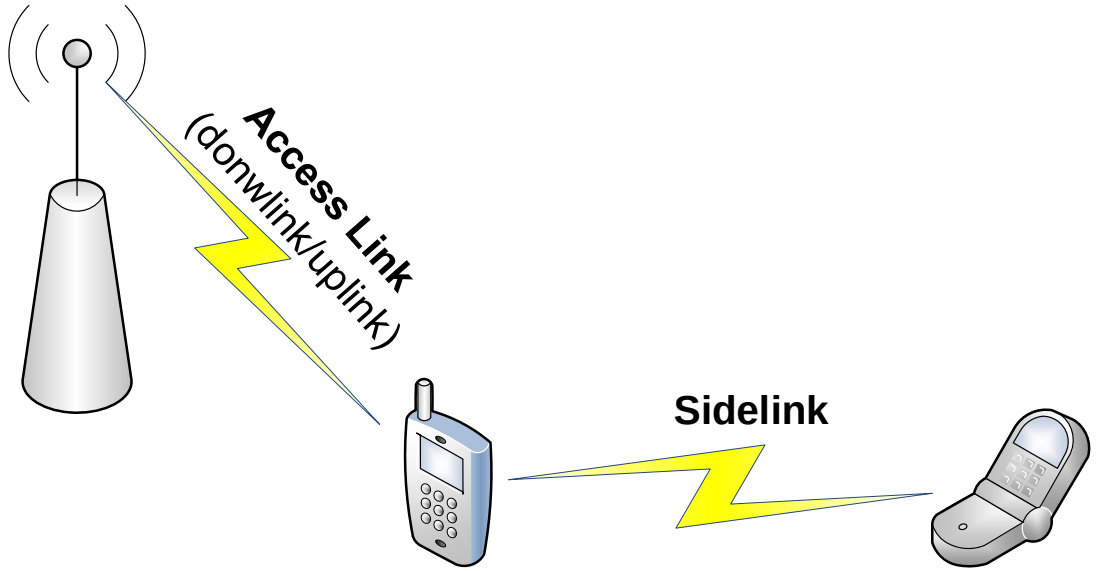
V2X (Sidelink)

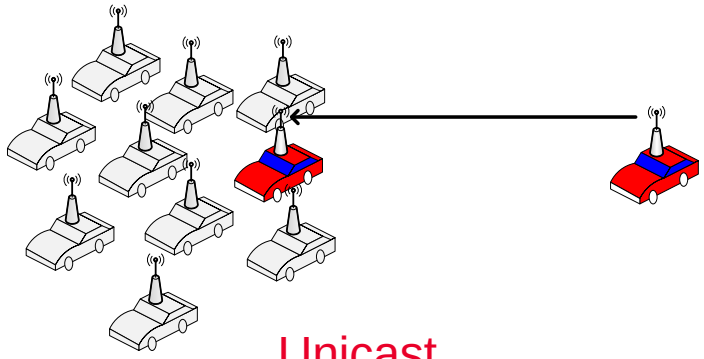
OVERVIEW OF NR REL-16 (RAN1)

- **Access link** between gNB and UEs (i.e. DL/UL)
- **Sidelink** (SL) between UEs
  - V2X is not the only possible use case for Sidelink
- NR sidelink **extends** LTE sidelink
  - Unicast
  - Groupcast
  - Broadcast

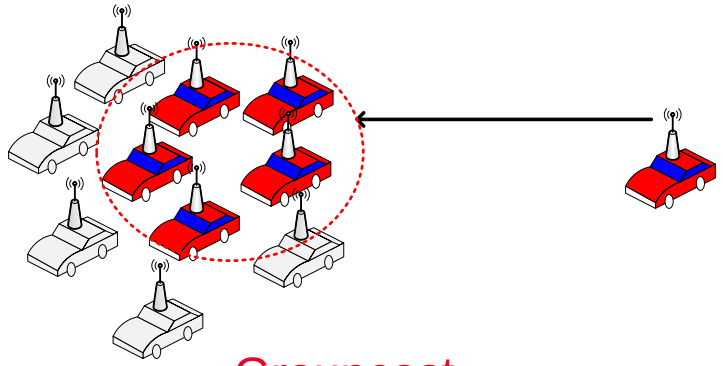
New to NR sidelink

Supported in LTE sidelink

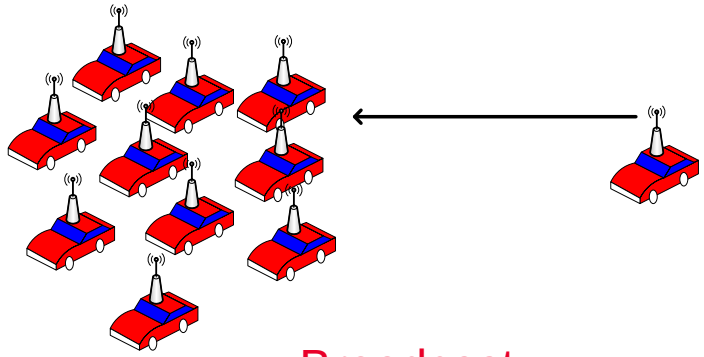




Unicast



Groupcast



Broadcast

Rel-16 Specifications

OVERVIEW OF NR REL-16 (RAN1)

- **No new spec series** for Rel-16
  - Rel-15/16 features are included in the same NR spec series (i.e. 38-series)
- Rel-16 specs are **available**
  - Spec stability is improving
  - Expect a extensive CR period until end of 2020

Spec	Title	Version
38.201	General Description	16.0.0
38.202	Services Provided by the Physical Layer	16.0.0
38.211	Physical Channels and Modulation	16.1.0
38.212	Multiplexing and Channel Coding	16.1.0
38.213	Physical Layer Procedures for Control	16.1.0
38.214	Physical Layer Procedures for Data	16.1.0
38.215	Physical Layer Measurements	16.1.0

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

3GPP TR 21.916 V0.5.0 (2020-07)

Technical Report

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
Release 16 Description;
Summary of Rel-16 Work Items
(Release 16)

5G

3GPP
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www.3gpp.org/specifications/releases

TR 21.916 presents the "initial state" of the Features introduced in Release 16.

An Executive Summary (Section 4) is to be added at the end, by the Work plan manager, when the majority of contributions have been submitted. Other sections of the Report are dedicated to summarising:

5	Enhancement of Ultra-Reliable (UR) Low Latency Communications (URLLC)
6	Support of LAN-type services
7	IoT
8	Advanced V2X support
9	Northbound APIs related items
10	Coexistence with Non-3GPP systems
11	Railways and Maritime
12	Mission Critical, Public Warning
13	Conversational services, Streaming and TV
14	5G Location and Positioning Services
15	User Identities, Authentication, multi-device
16	Network Slicing
17	UE radio capability signalling optimization
18	Other system-wide Features: PARLOS , ETSUN, NG_RAN_PRN, eSBA, Network Automation for 5G, UDICOM
19	Radio Features: NR-related Release 16 Features Release 16 Features impacting both LTE and NR LTE-related Release 16 Features
20	Other Release 16 Features
21	Telecom Management

Introduction to NR Rel-17 (RAN1)

Rel-17 Content Summary

INTRODUCTION TO NR REL-17 (RAN1)

NR Rel-17

Rel-17 TEIs

Rel-17 New Features

Capacity and operational efficiency

- MIMO enhancements
- Sidelink enhancements
- DSS enhancements
- IIoT/URLLC enhancements
- Positioning enhancements
- Power saving enhancements
- Coverage enhancements

Vertical expansion

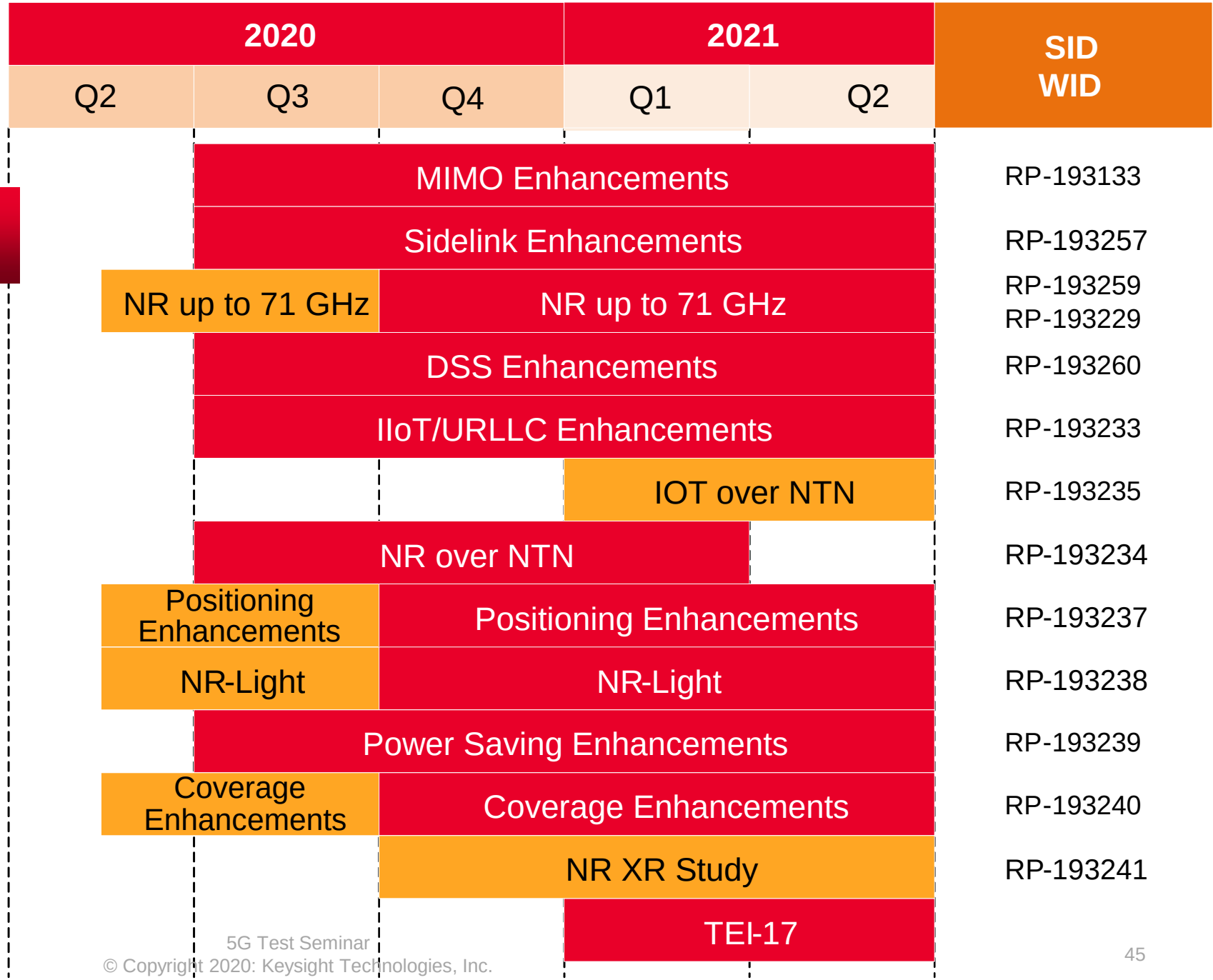
- NR up to 71 GHz
- NR over NTN
- NR-Light

Rel-17 Workplan (RAN1)

INTRODUCTION TO NR REL-17 (RAN1)

Study Item

Work Item



NR up to 71 GHz

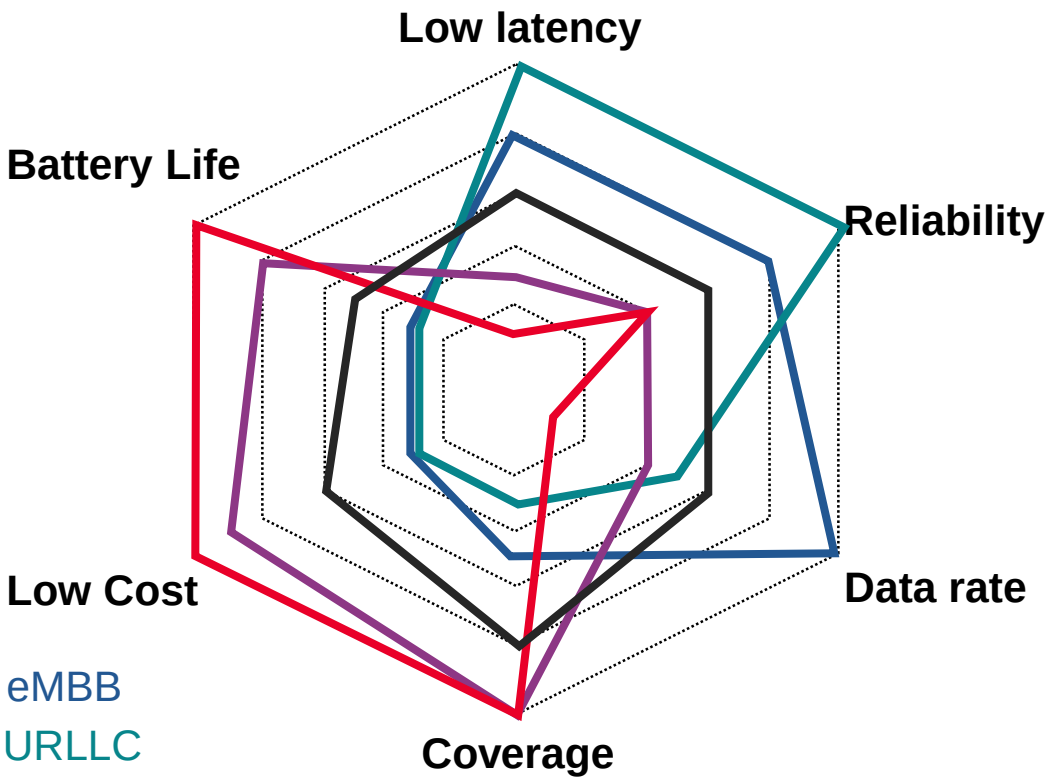
INTRODUCTION TO NR REL-17 (RAN1)

- Rel-15 and Rel-16 are defined up to **52.6GHz**
- **Challenges**
  - Higher phase noise, larger propagation loss, power amplifier efficiency, regulatory requirements in unlicensed bands, …
- **Advantages**
  - Larger spectrum allocations and larger bandwidths
- **Using existing DL/UL NR waveform** to support between 52.6GHz and 71GHz
  - Numerology impact
  - Physical layer design impact

- **Use cases**
  - High data rate eMBB
  - Mobile data offloading
  - Short range high-data rate D2D communications
  - Broadband distribution networks
  - Integrated access backhaul (i.e. IAB)
  - Industrial IoT (i.e. IIoT)
  - AR/VR wearables
  - Intelligent transport systems (i.e. ITS) and V2X
  - Smart grid automation
  - Private networks
  - Support of high positioning accuracy
  - …

NR-Light

INTRODUCTION TO NR REL-17 (RAN1)



- **Use cases**
  - Connected industries, smart city, wearables, …
- **Requirements**
  - Lower the device cost and complexity
- **Complexity reduction features**
  - Number of antennas, bandwidth, HD-FDD, processing capabilities, …
- **Power saving enhancements**
  - PDCCH monitoring
- **Mitigation of performance degradation**
  - Coverage recovery to compensate for potential coverage reduction due to the device complexity reduction

DSS Enhancements

INTRODUCTION TO NR REL-17 (RAN1)

- **Dynamic Spectrum Sharing** (i.e. DSS) provides a very useful migration path from LTE to NR by allowing LTE and NR to share the same carrier
- DSS was included already in Rel-15 and further enhanced in Rel-16

- **Problem**
  - As the number of NR devices in a network increases there are not enough NR scheduling resources in the shared carriers
- **Solution**
  - Increase network scheduling capacity for NR UEs on the shared carriers
  - PDCCH enhancements for cross-carrier scheduling including

Sidelink Enhancements

INTRODUCTION TO NR REL-17 (RAN1)

- **Power saving**
  - Enables UEs with battery constraint to perform sidelink operations in a power efficient manner
  - Rel-16 NR sidelink is designed based on the assumption of “always-on” when UE operates sidelink
    - Only focusing on UEs installed in vehicles with sufficient battery capacity
  - **Solutions for**:
    - Vulnerable road users (VRUs) in V2X
    - UEs in public safety
- Support of **URLLC-type sidelink use cases** in wider operation scenarios
  - The system level reliability and latency performance of sidelink is expected to have limitation in achieving high reliability and low latency in some conditions (e.g., when the channel is relatively busy)

REF:RP-192745

IIoT and URLLC Enhancements

INTRODUCTION TO NR REL-17 (RAN1)

- Latency and reliability performance of NR are keys to support use cases with tighter requirements
- **Rel-16** introduced support and enhancements for:
  - Release 15 enabled use case improvements such as AR/VR
  - New use cases with higher requirements:
    - Factory automation
    - Transport industry
    - Electrical power distribution
- **Goals**
  - Required ***physical layer feedback enhancements*** for meeting URLLC requirements
  - ***Intra-UE multiplexing*** and prioritization of traffic with different priority based on work done in Rel-16

REF: RP-193260

Power Saving Enhancements

INTRODUCTION TO NR REL-17 (RAN1)

- UE power saving enhancements are vital to the success of NR
- **Rel-16** introduces several useful power saving schemes:
  - Power saving signal/DCI as enhancement to connected-mode DRX
  - Additional adaptations to maximum MIMO layer number
  - SCell dormancy behavior and cross-slot scheduling as enhancements to BWP framework
  - RRM relaxation as enhancements for idle/inactive-mode power consumption
  - UE assistance information
- **Rel-17** must introduce additional enhancements:
  - ***Idle/inactive-mode*** power consumption in ***NR SA deployments***
    - Considering both ***eMBB UEs*** and ***reduced capability NR devices***
  - ***Connected-mode power consumption*** with ***FR2 deployments***
  - optimizing network utilization of Rel-16 ***UE assistance information***

Non-Terrestrial Networks

INTRODUCTION TO NR REL-17 (RAN1)

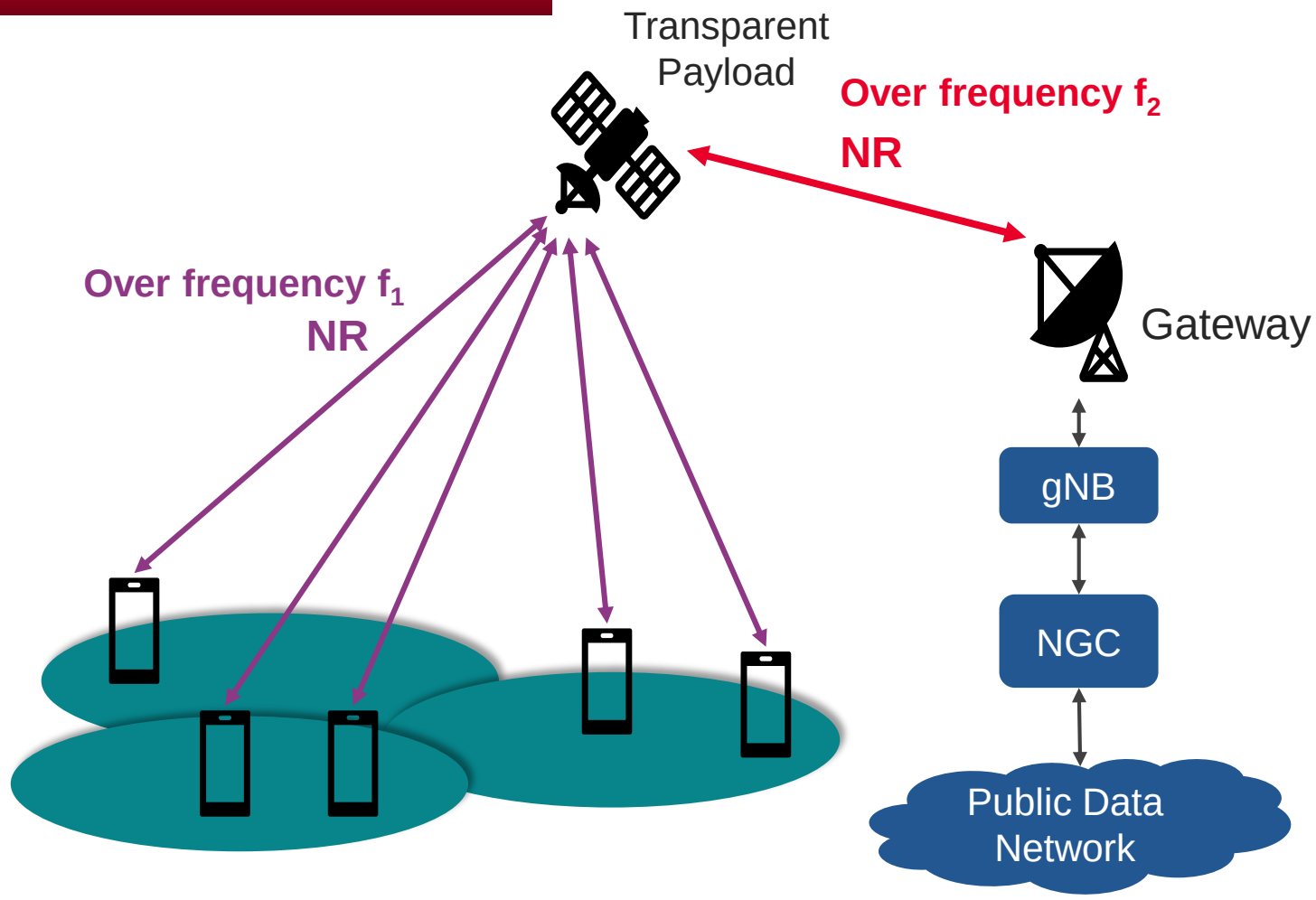
- Spaceborne vehicles:
  - Low Earth Orbiting (LEO) satellites
  - Medium Earth Orbiting (MEO) satellites
  - Geostationary Earth Orbiting (GEO) satellites
  - Highly Elliptical Orbiting (HEO) satellites
- Airborne vehicles

- **Extend** and **complement** terrestrial networks in:
  - Unserved and under served areas
  - Improve service reliability thanks to a better service continuity (e.g. mission critical communications)
  - Efficient multicast/broadcast data delivery
- **Advantages**
  - Wide-area coverage (i.e. large footprint)
  - Reduced vulnerability to physical attacks or natural disasters
- **Challenges** to the realisation of a satellite-based NR network:
  - Large path losses
  - Large delays
  - Large Doppler shifts
- Cornerstone in the realisation of the foreseen **heterogeneous global system**

Non-Terrestrial Networks

INTRODUCTION TO NR REL-17 (RAN1)

- **Supported Scenarios**
  - **Transparent payload** based LEO scenario
  - **Transparent payload** based GEO scenario
- **Transparent Payload (i.e. bent-pipe)**
  - The NR signals are generated from gNBs located on ground
  - The satellite is equivalent to a Radio Frequency (RF) Remote Unit
  - Transparent to the NR protocols (including the physical layer)



Direct user access link with gNB on the ground

Summary

Summary

- NR is a **fast evolving standard**
  - **Rel-15** was completed in 2018
  - **Rel-16** will be completed by June 2020
  - **Rel-17** has started in May 2020
- New releases include efficiency, capacity and operational **enhancements** to NR
  - e.g. MIMO, power saving, DSS, multi-TRP, …
- New releases also expand NR to **new verticals**
  - E.g. IIoT, V2X, NR-U, NTN, NR-Light, …
- Many **new features** coming in Rel-16 and Rel-17
  - Increased testing needs
  - Need for fast innovation
- The situation caused by COVID-19 is **impacting Rel-17 deadlines**

Links

- 3GPP Webpage
  - www.3gpp.org
- Keysight 5G Products and Solutions
  - www.keysight.com/find/5G
- Keysight's 5G Webcasts and Webinars
  - www.keysight.com/find/5Gwebinars