



**KEYSIGHT
WORLD 2020**

5G NR Standard Evolution 3GPP RAN1 Update (Release 16 & 17)

Senior Application Project Manager

JianHua Wu



5G NR Standard Evolution: 3GPP RAN1 Update

3GPP RAN1
NR Situation
Update

Overview of
NR Rel-16
(RAN1)

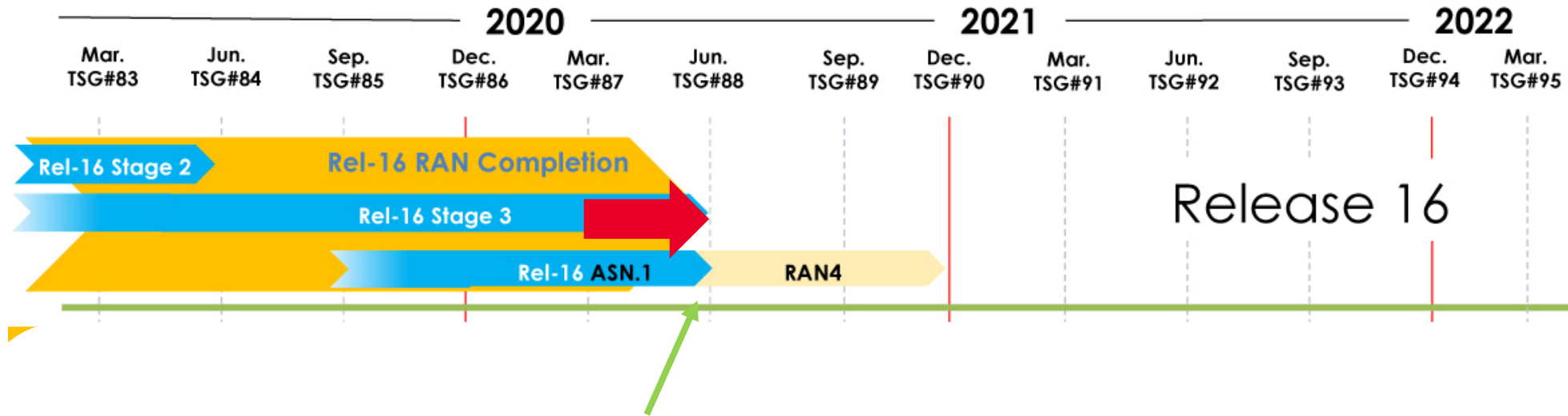
Introduction to
NR Rel-17
(RAN1)

Summary

3GPP RAN1 NR Situation Update



Summary of NR RAN1 Work



March 23, 2020 Update:

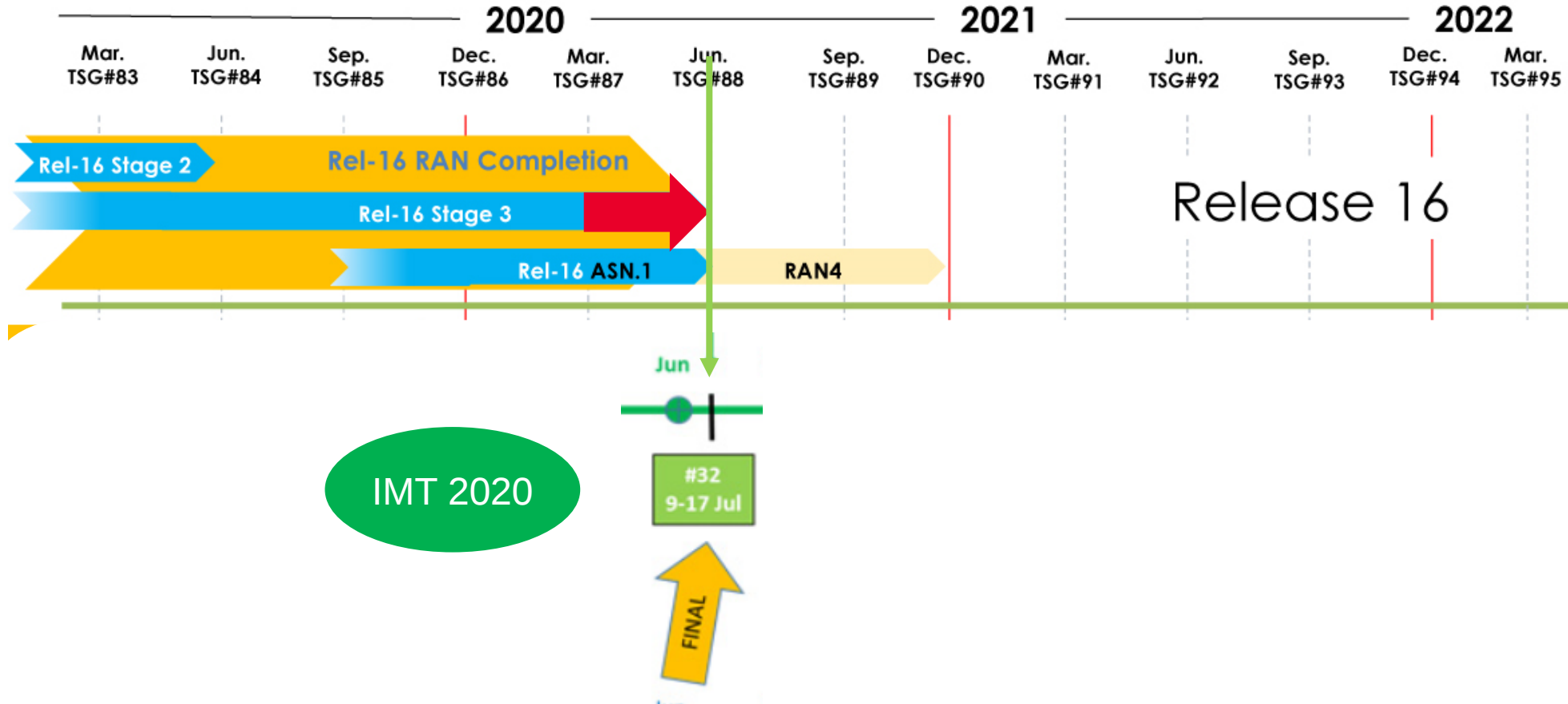
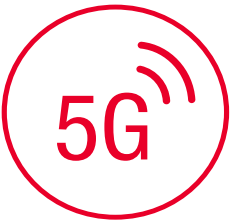
A shift of the Rel-16 timeline was approved at TSG#87 plenary e-meetings:

- 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)

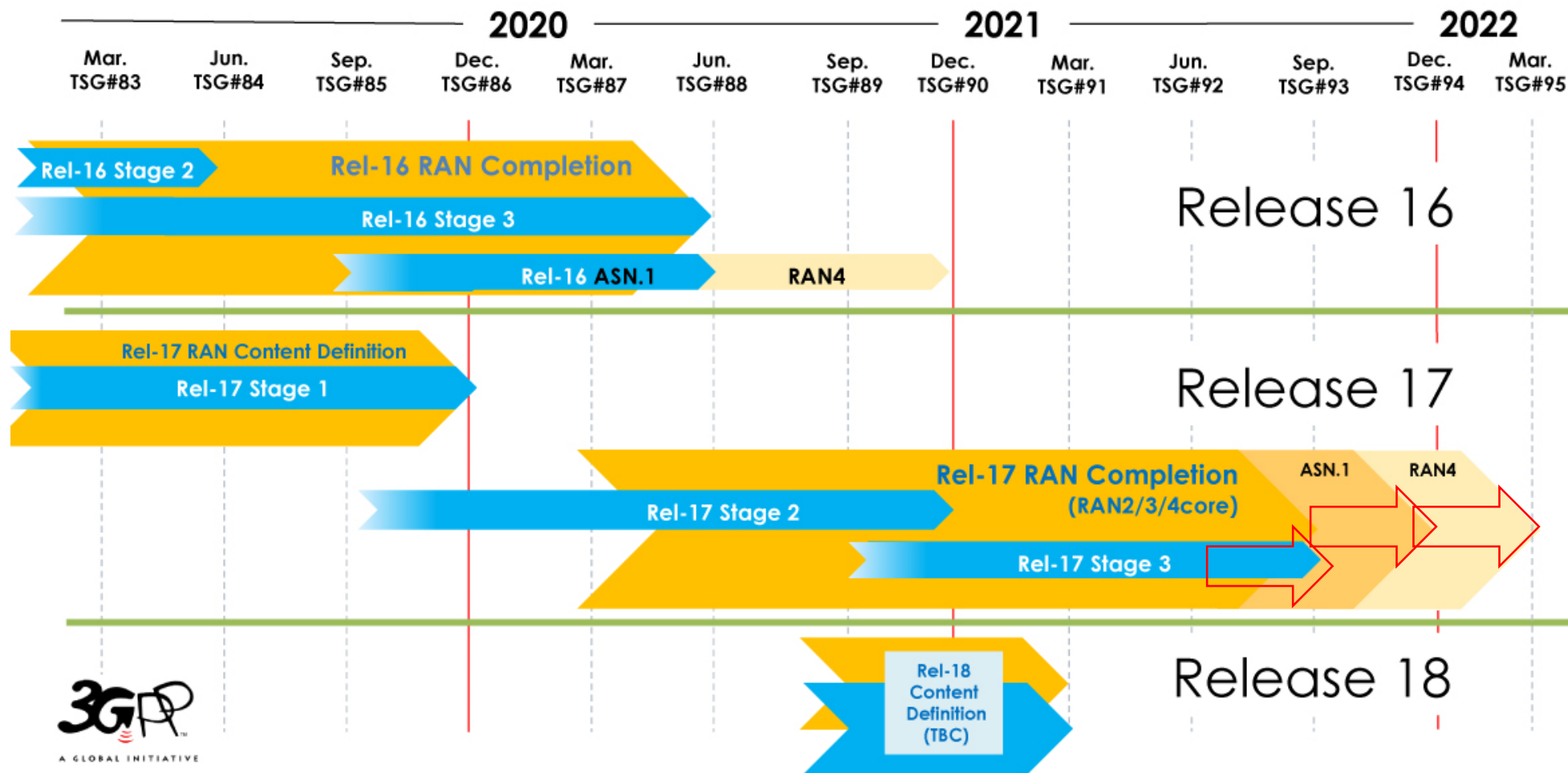


REF: <https://www.3gpp.org/release-16>

Summary of NR RAN1 Work



Summary of NR RAN1 Work



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

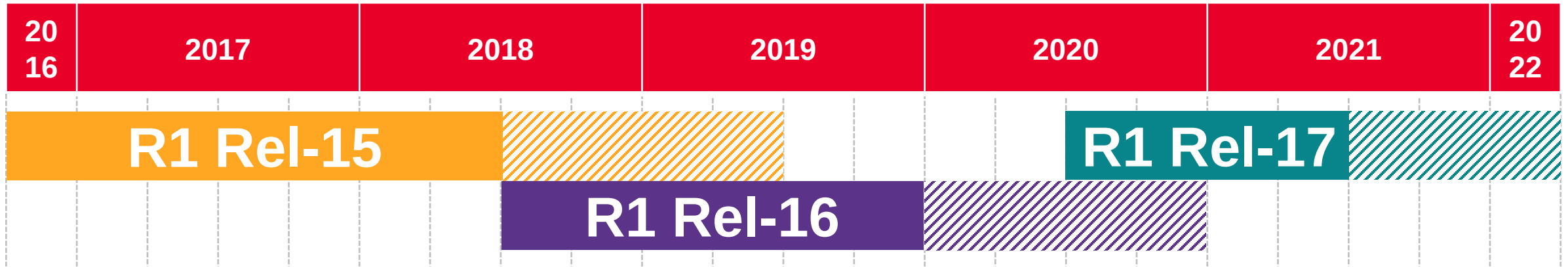
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REF: <https://www.3gpp.org/release-16>

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



Rel-15

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

Stable

mMTC

Massive Machine Communication



Rel-16

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

Stabilizing

URLLC

Mission-Critical Machine Communication



Rel-17

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

Started

eMBB

Mobile Broadband Access



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Stabilizing

URLLC

Mission-Critical Machine Communication



Rel-17

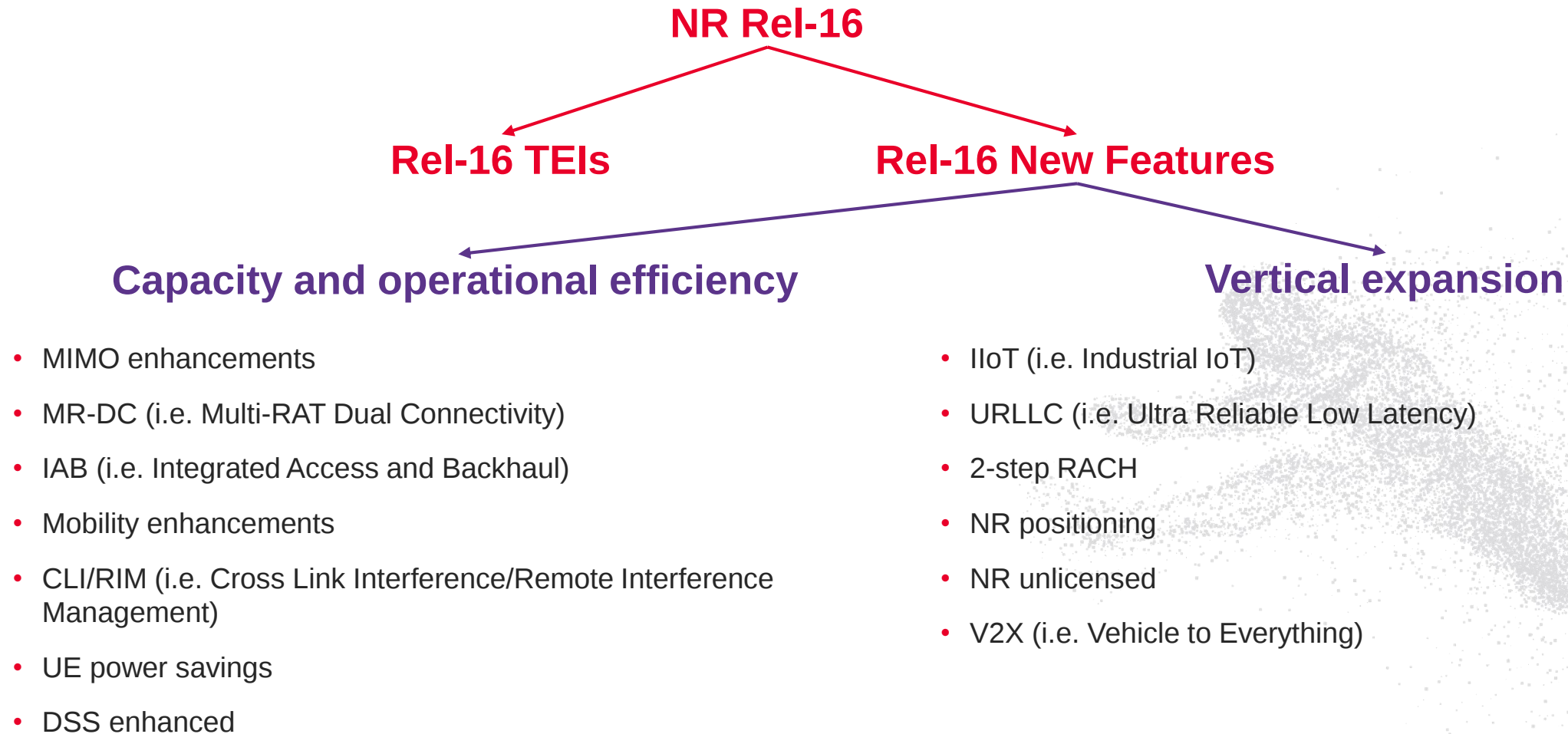
- NR up to 71 GHz
- NTN
- NR-Light
- Enhancements
- ...

Started

Overview of NR Rel-16 (RAN1)

Rel-16 Content Summary

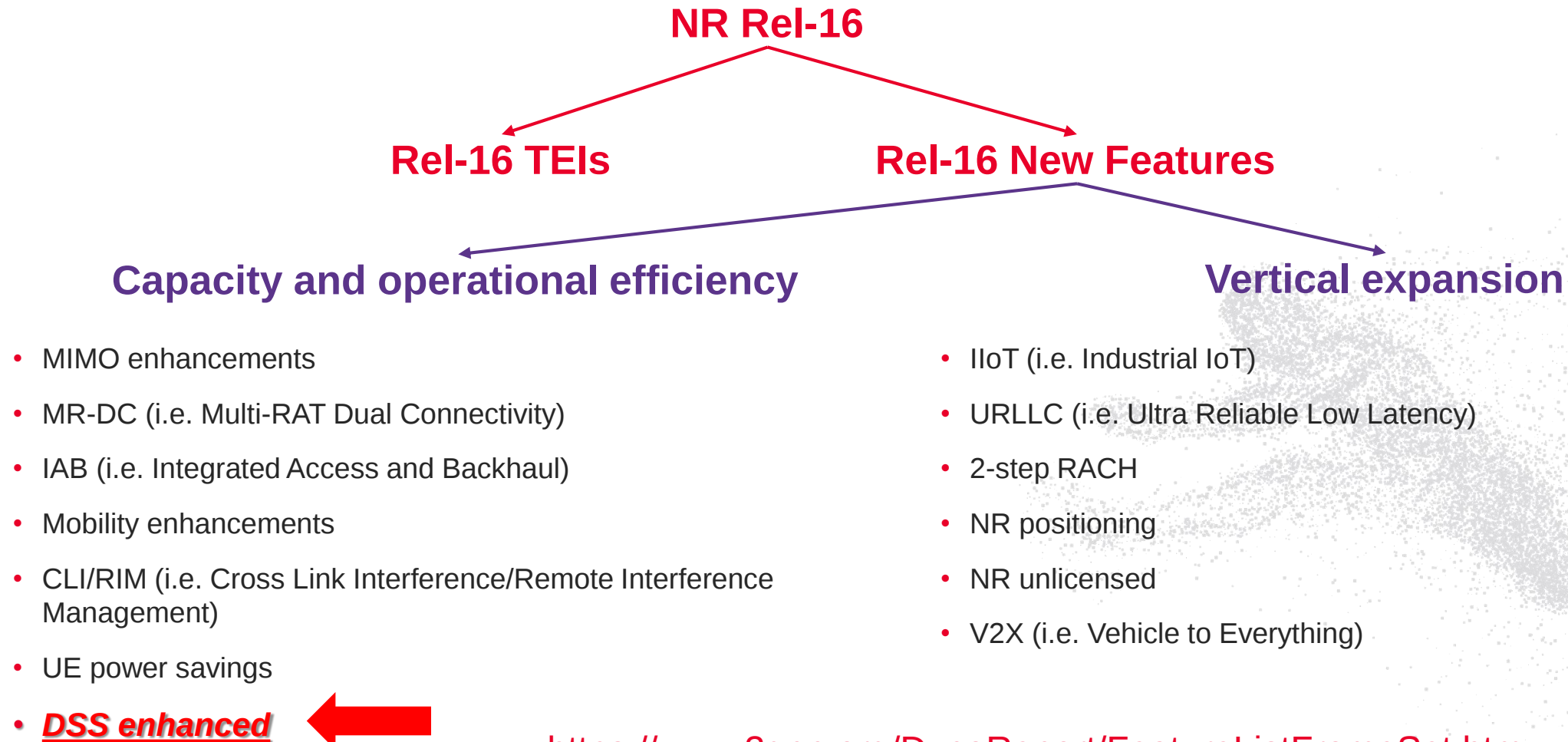
OVERVIEW OF NR REL-16 (RAN1)



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

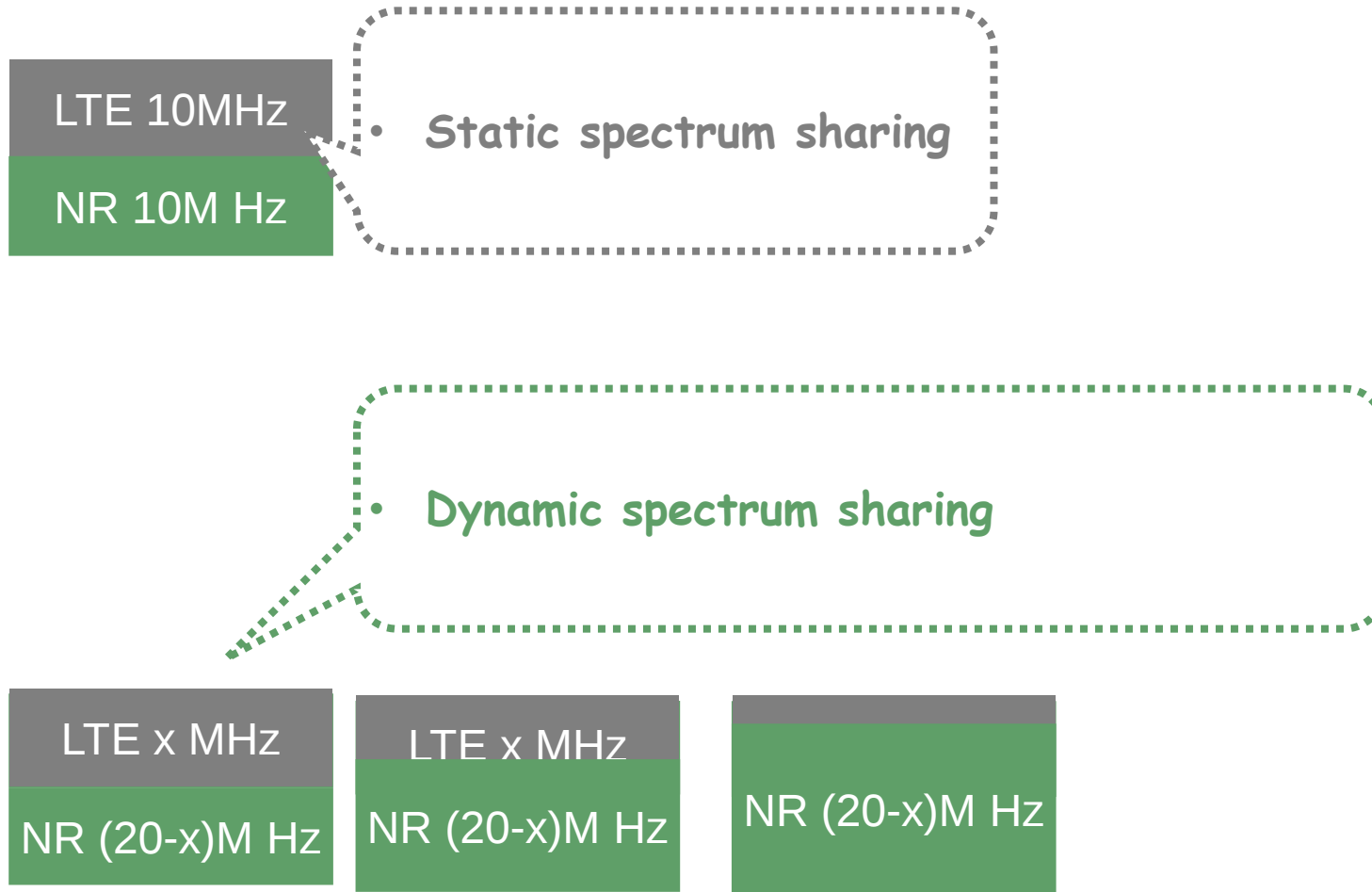
Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)



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

Static spectrum sharing VS Dynamic spectrum sharing

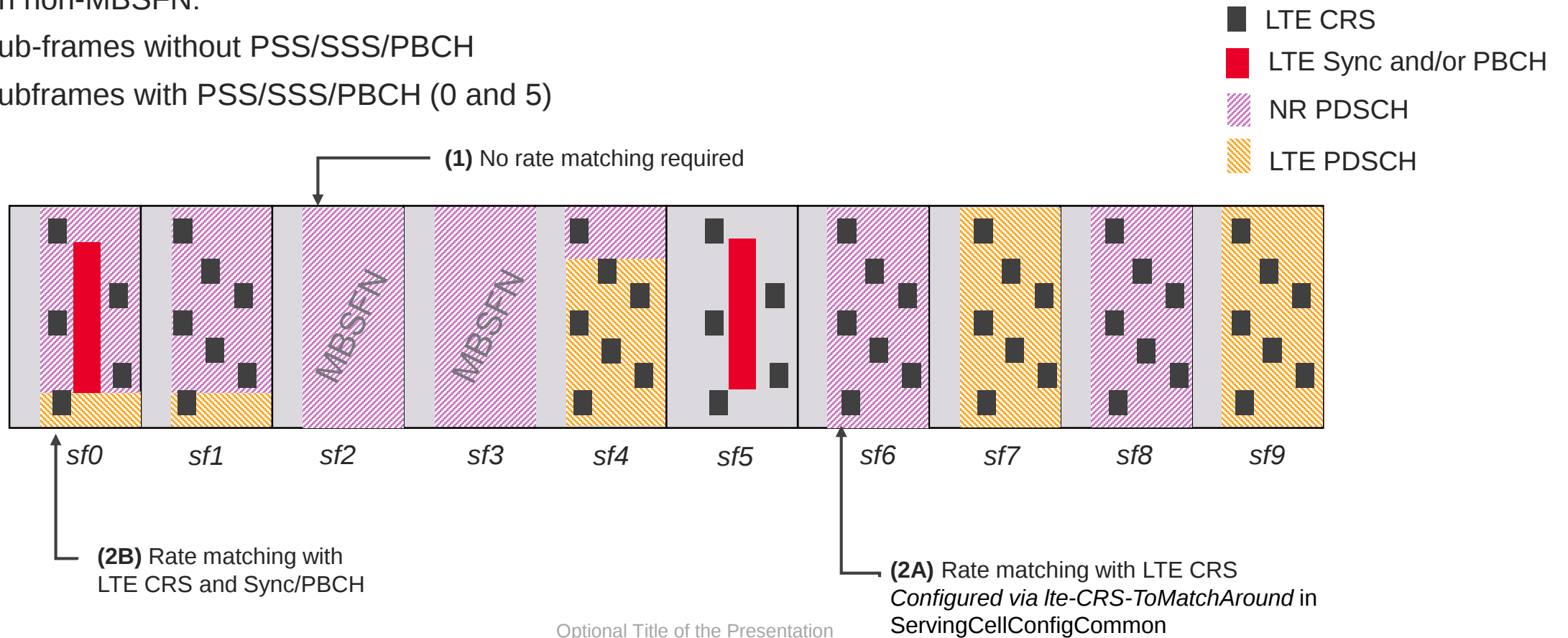


DSS Case

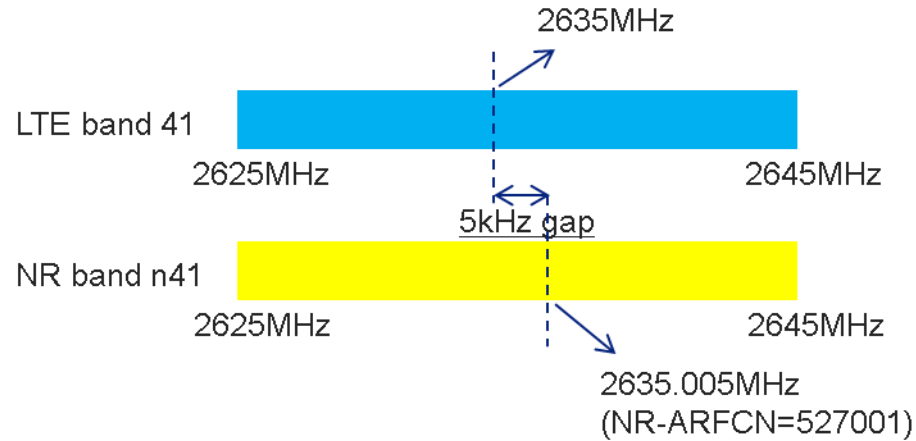
DIFFERENT USE CASES

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)			Bandwidth DL/UL (MHz)	Uplink (MHz)			Duplex spacing (MHz)	Geographical area	3GPP release
					Low	Middle	High		Low	Middle	High			
										nr-arfcn			nr-arfcn	
n41	TD 2600+	TDD	15	3	2496	2593	2690	194				Global	15.0	
			30	6	499200	518601	537999							
					499200	518598	537996							
n90	TD 2600+	TDD	15	3	2496	2593	2690	194				Global	16.0	
			30	6	499200	518601	537999							
			100	20	499200	518600	538000							

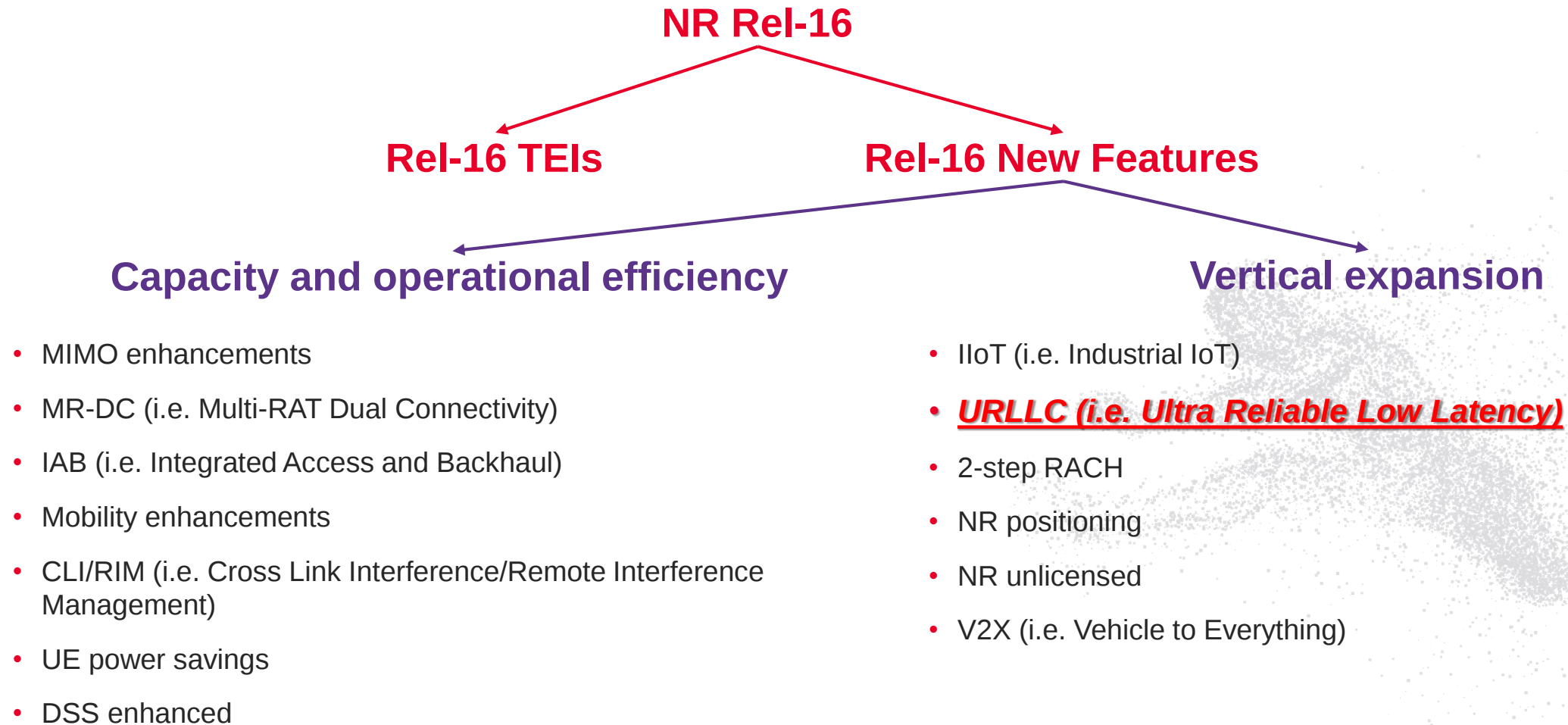
Keysight World

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

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)



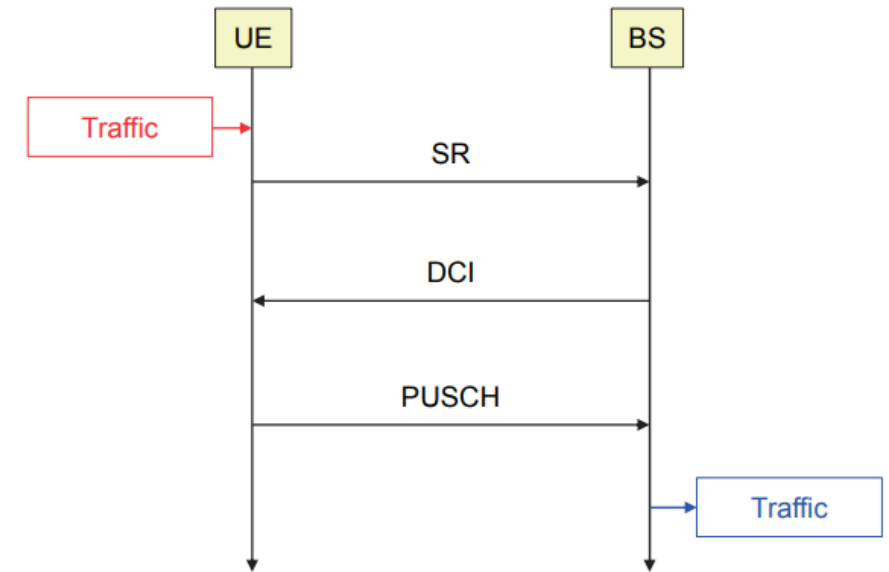
<https://www.3gpp.org/DynaReport/FeatureListFrameSet.htm>

URLLC Enhancement

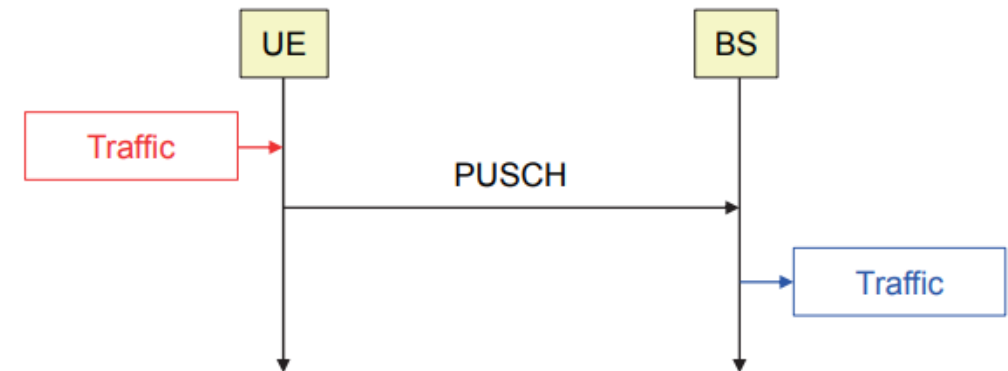
- **Release 15** enabled use case improvements
 - Such as AR/VR (Entertainment industry)
- **New Release 16** use cases with higher requirements
 - Factory automation
 - Transport Industry, including the remote driving use case
 - Electrical Power Distribution
- **Rel-15:** basic URLLC functionality
 - **Low latency:** larger subcarrier spacing, mini-slots, configured grant, ...

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

(a) Dynamic grant

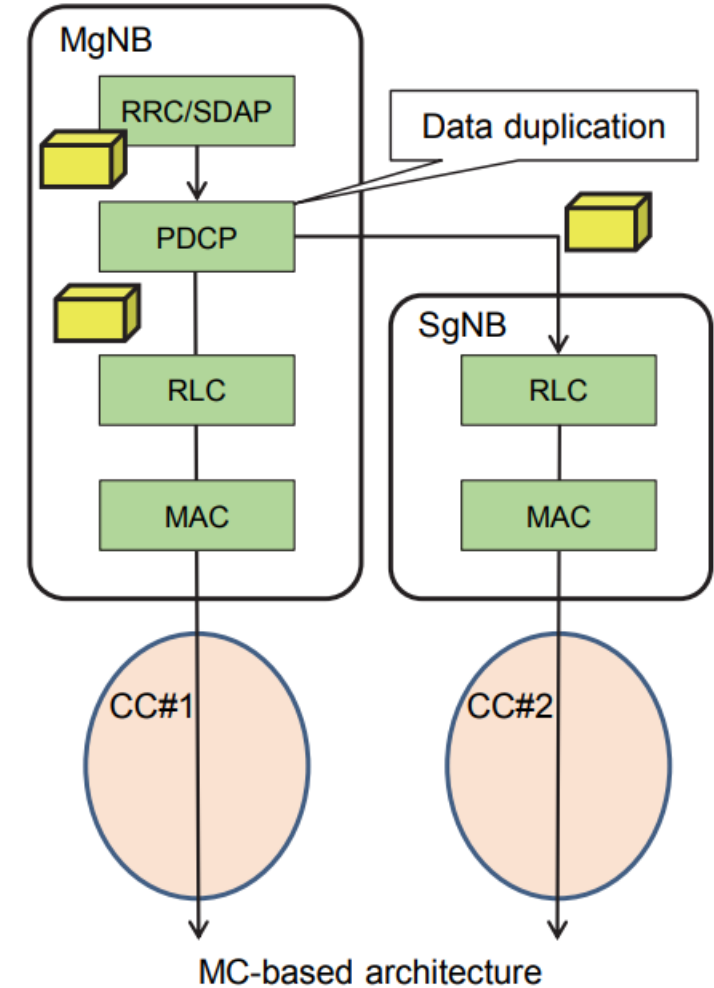
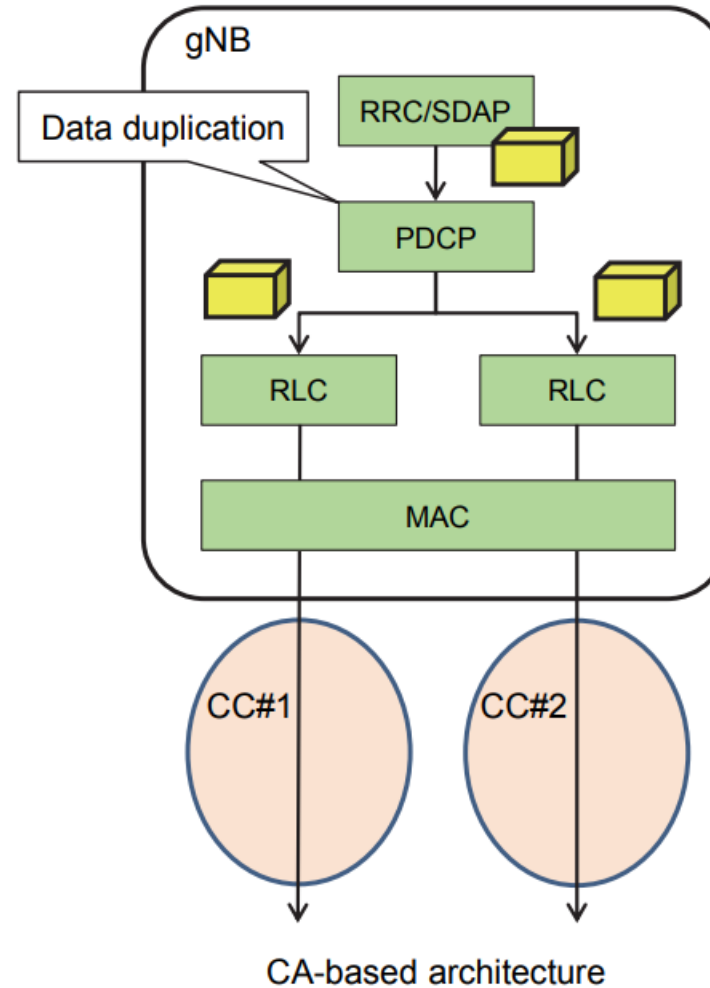


(b) Configured grant



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

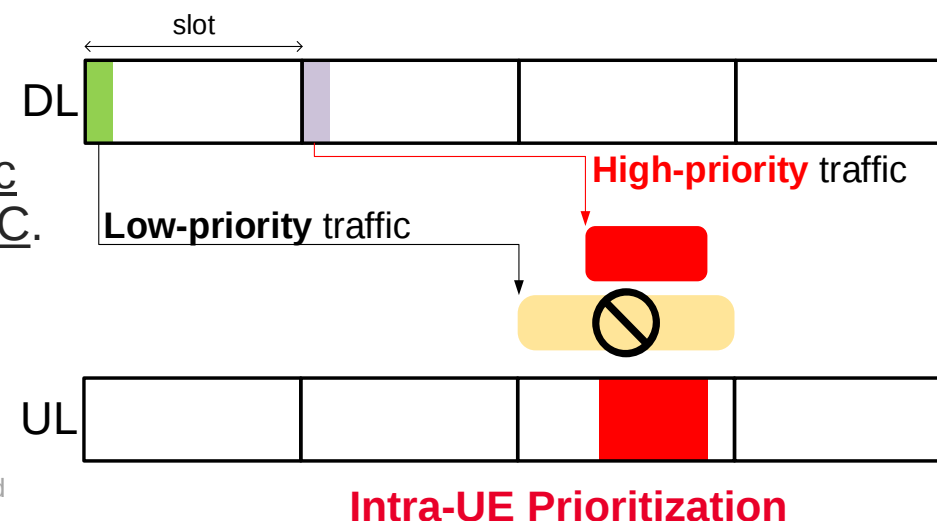
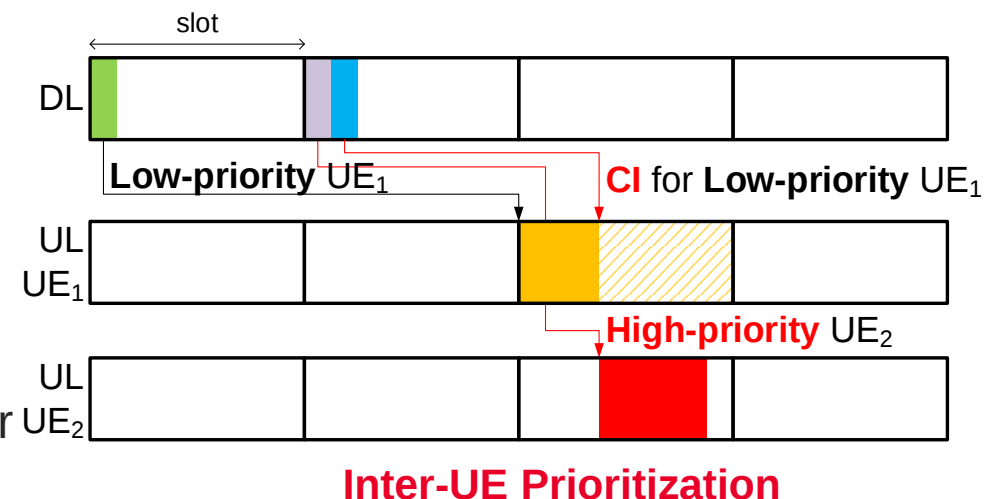
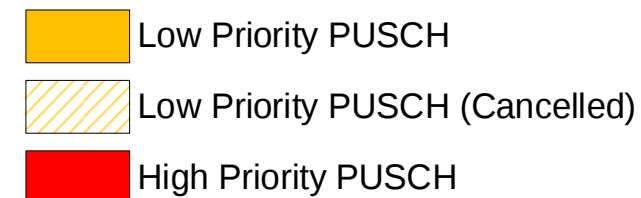
Table 5.1.3.1-3: MCS index table 3 for PDSCH

MCS Index I_{MCS}	Modulation Order Q_m	Target code Rate $R \times [1024]$	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

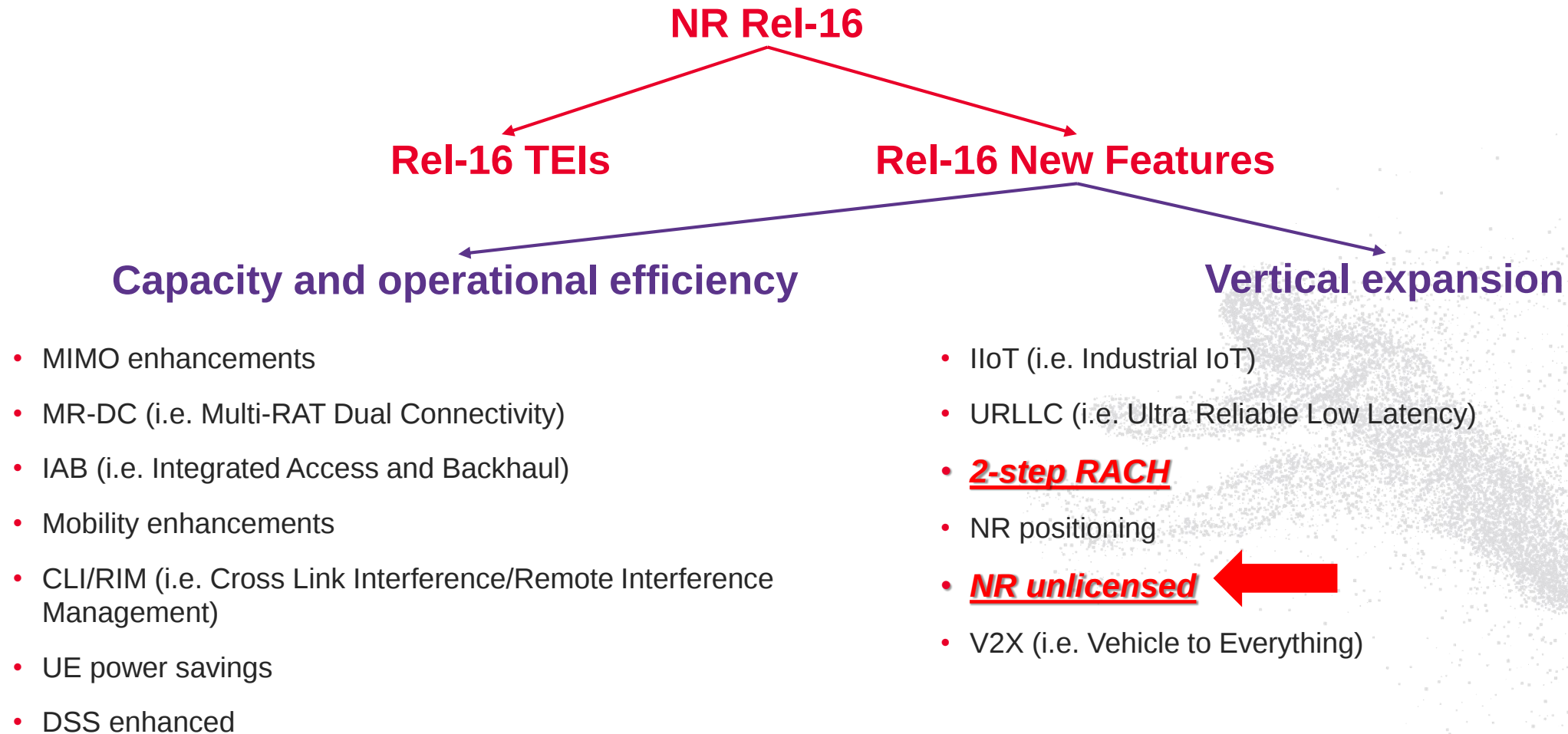
OVERVIEW OF NR REL-16 (RAN1)

- **UE Tx prioritization/multiplexing**
 - **Inter-UE** Tx prioritization and multiplexing
 - **Intra-UE** Tx prioritization and multiplexing
- **PUSCH enhancements** :
 - 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
- **Specification of PDCCH/UCI enhancements**
- **Enhanced power control** :
 - dynamic power boost for URLLC UE, including dynamic change of power control parameters and enhanced TPC.
(see section 7.2.2 in TR 38.824)



Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)



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

Unlicensed Spectrum

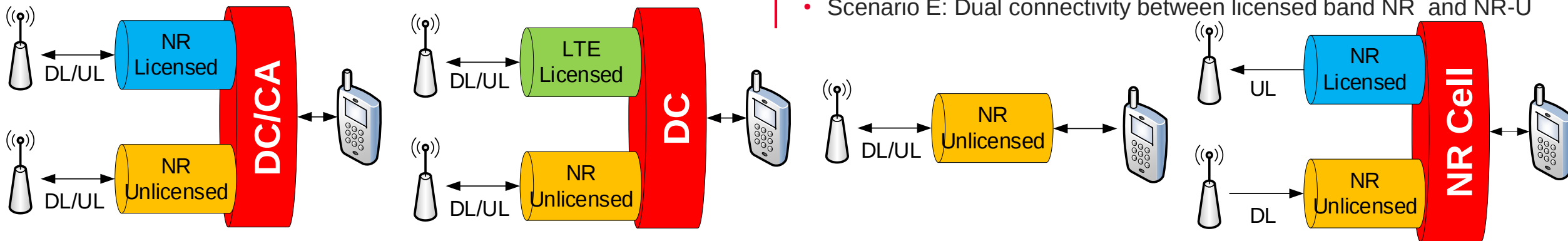
OVERVIEW OF NR REL-16 (RAN1)

• 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.

• 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)

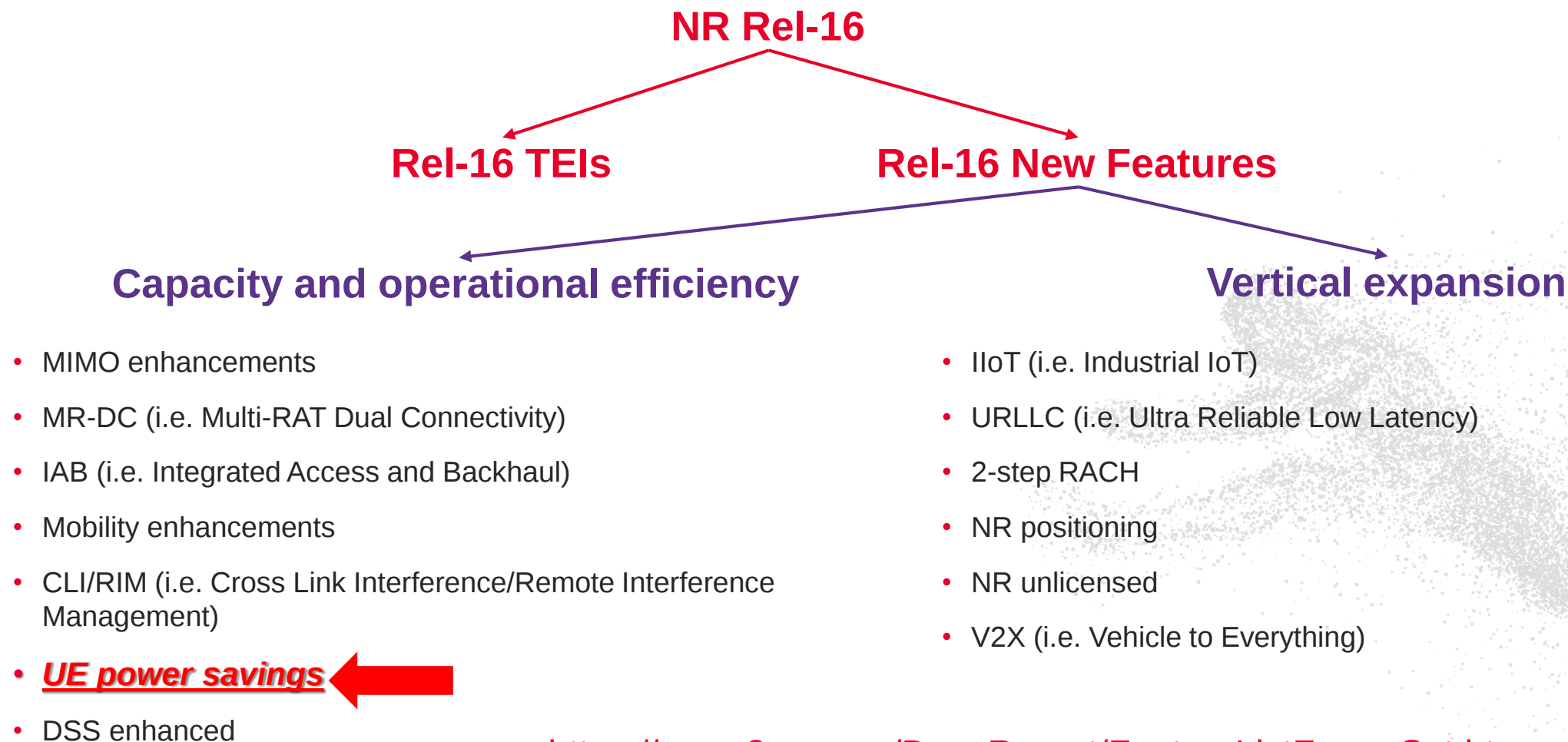
- Physical layer aspects

- 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

- 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.

Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)



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

UE Power Saving

OVERVIEW OF NR REL-16 (RAN1)

RP-200494

- **Power saving techniques**

- Time domain
- DRX configuration
- Frequency domain
- Antenna domain
- UE processing time
- RRM measurements relaxation
- Reduced PDCCH Monitoring
- ...

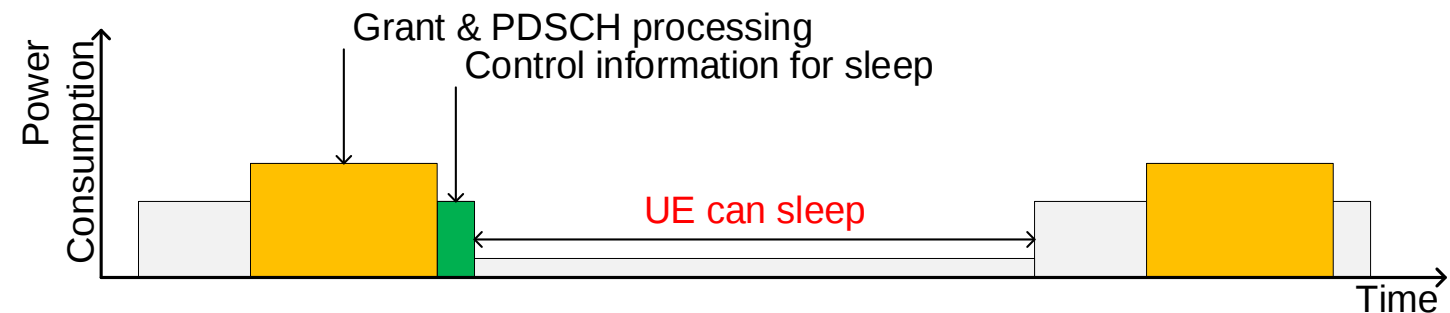
- **PDCCH-Based Power Saving**

- **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
- Indicated using new DCI format



UE Power Saving

OVERVIEW OF NR REL-16 (RAN1)

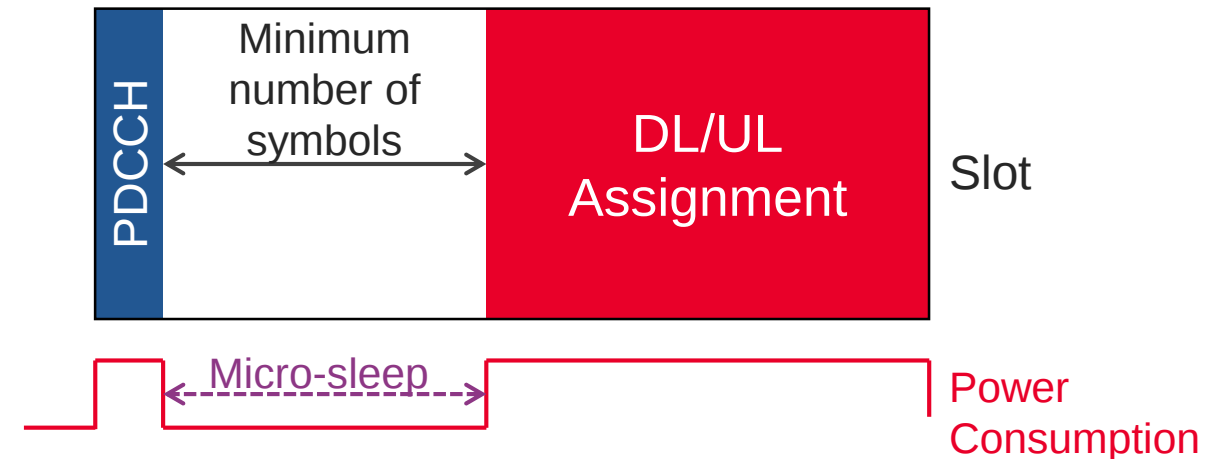
RP-200494

- **Power saving techniques**

- Time domain
- DRX configuration
- Frequency domain
- Antenna domain
- UE processing time
- RRM measurements relaxation
- Reduced PDCCH Monitoring
- ...

- **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)

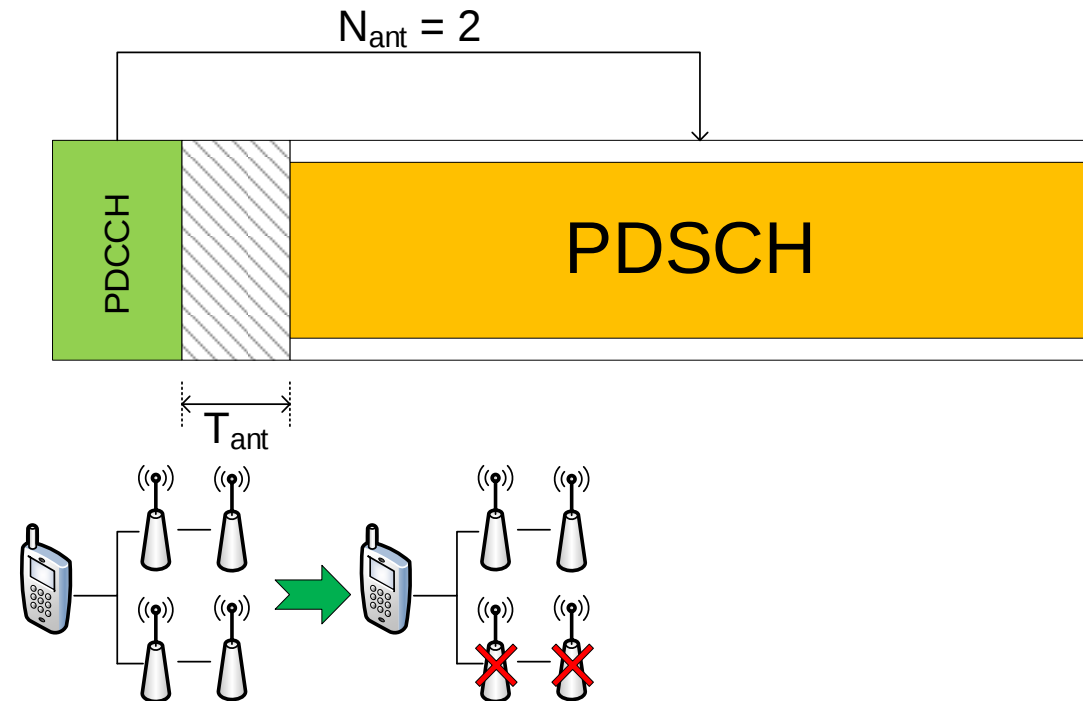
RP-200494

- **Power saving techniques**

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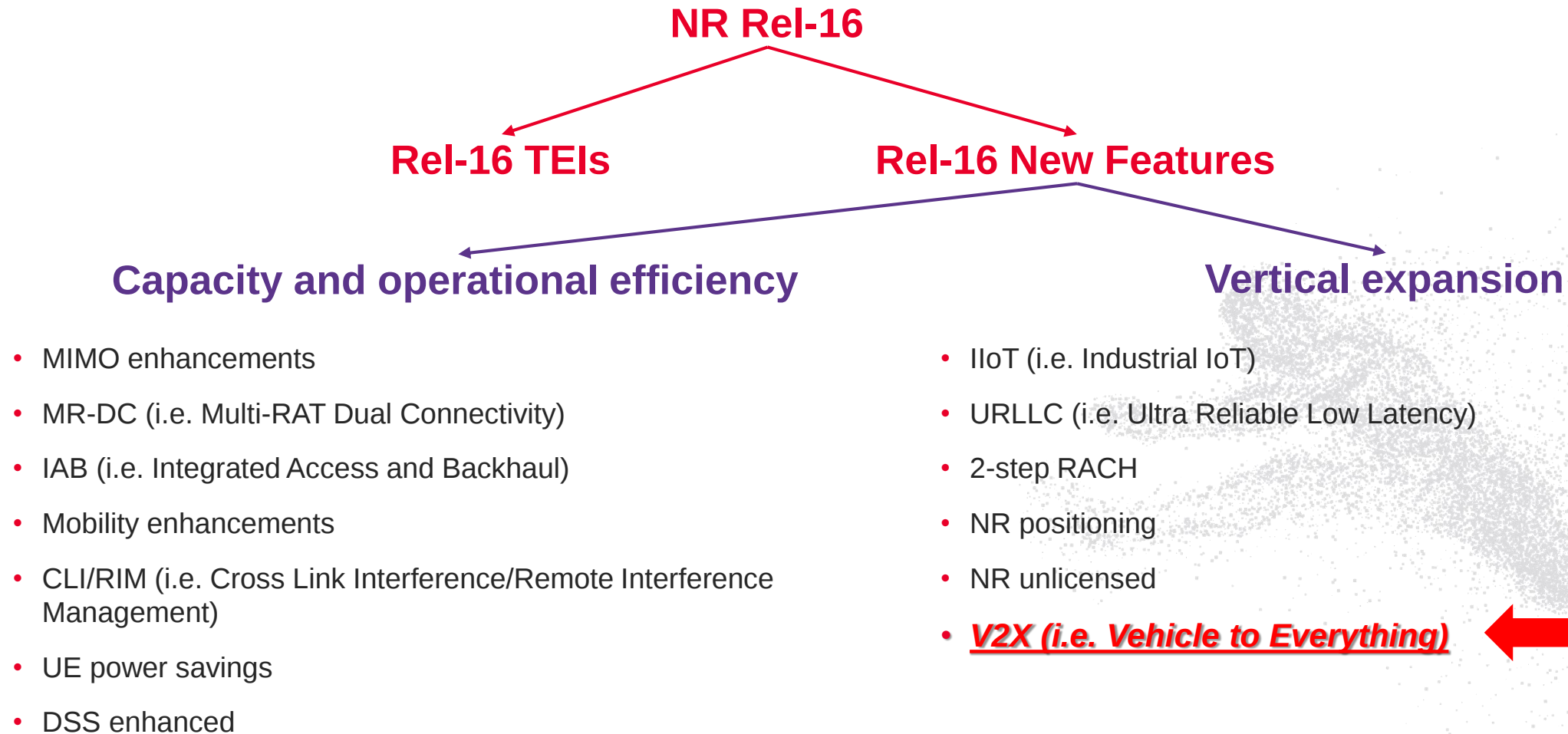
- **MIMO Layer Adaptation**

- Reduce the number of DL MIMO layers
- Allows the UE to reduce the number of antennas



Rel-16 Content Summary

OVERVIEW OF NR REL-16 (RAN1)



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

V2X (Sidelink)

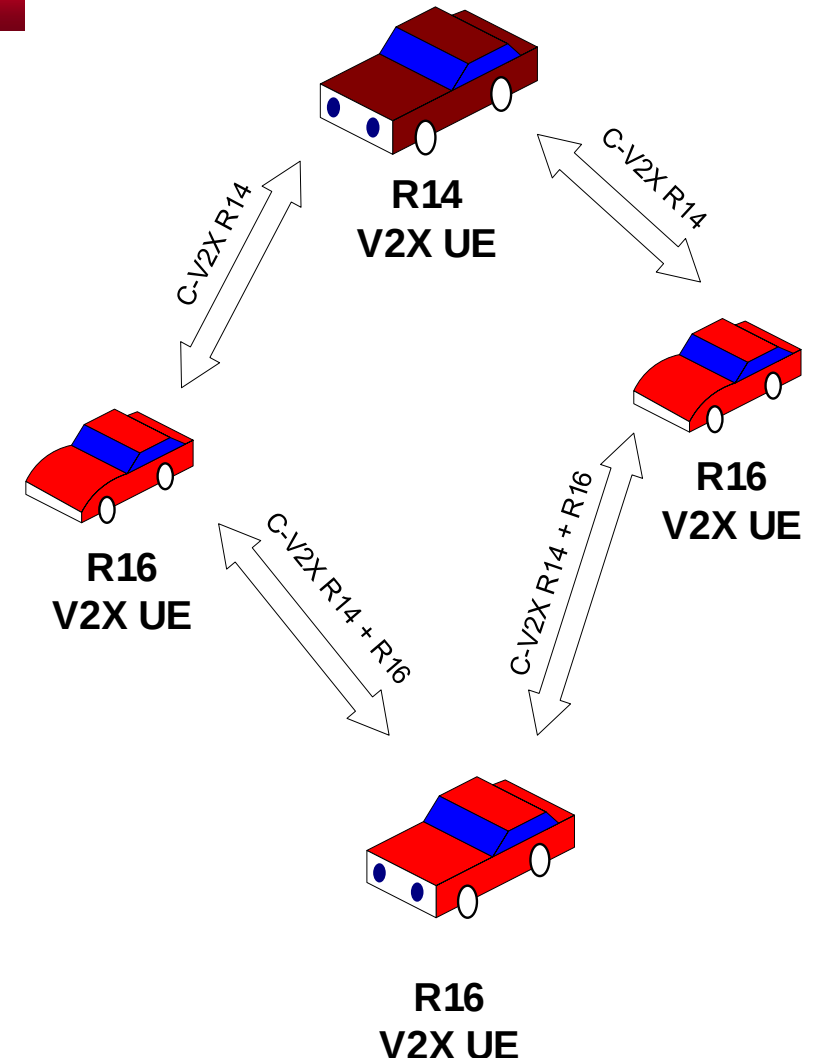
OVERVIEW OF NR REL-16 (RAN1)

- **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**

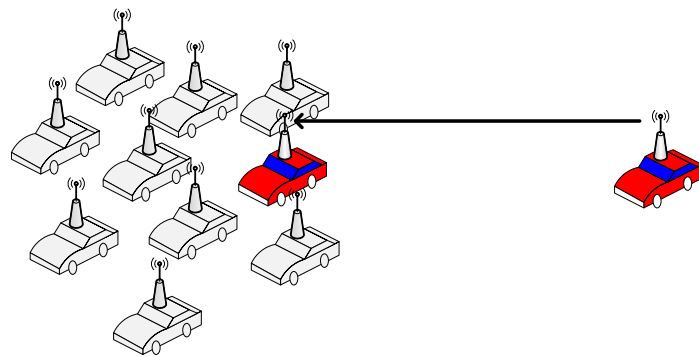
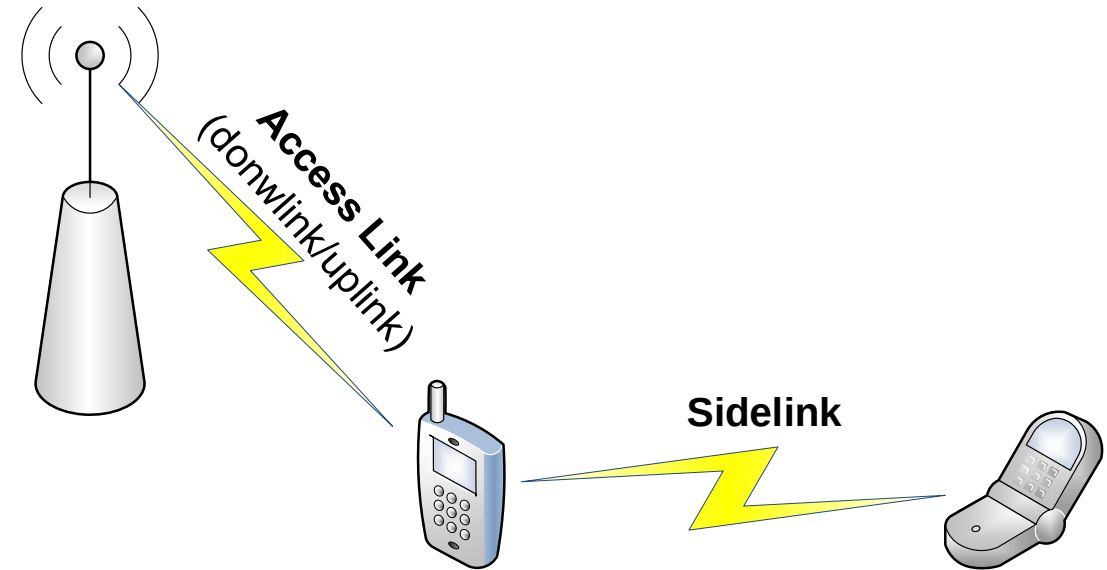
- Increased situational awareness, sensor sharing, coordinated driving and intention sharing, real-time infrastructure updates, ...



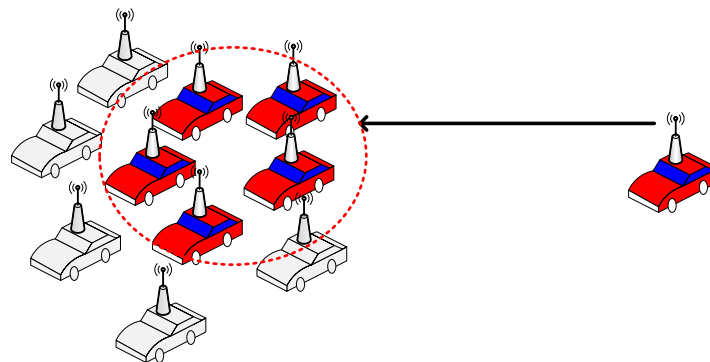
V2X (Sidelink)

OVERVIEW OF NR REL-16 (RAN1)

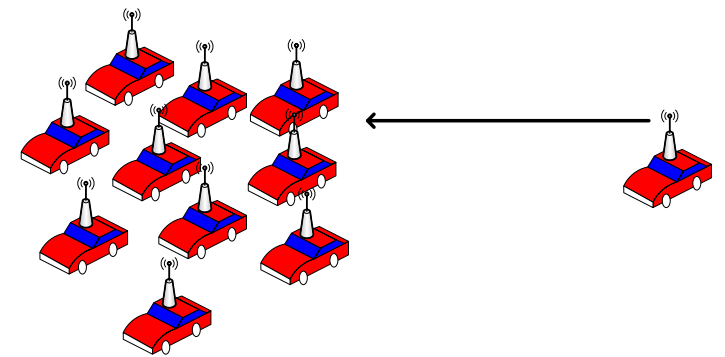
- **Access link** between gNB and UEs (i.e. DL/UL)
 - **Sidelink** (SL) between UEs
 - V2X is not the only possible use case for Sidelink
 - NR sidelink **extends** LTE sidelink
 - Unicast
 - Groupcast
 - Broadcast
- ← New to NR sidelink
- ← Supported in LTE sidelink



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

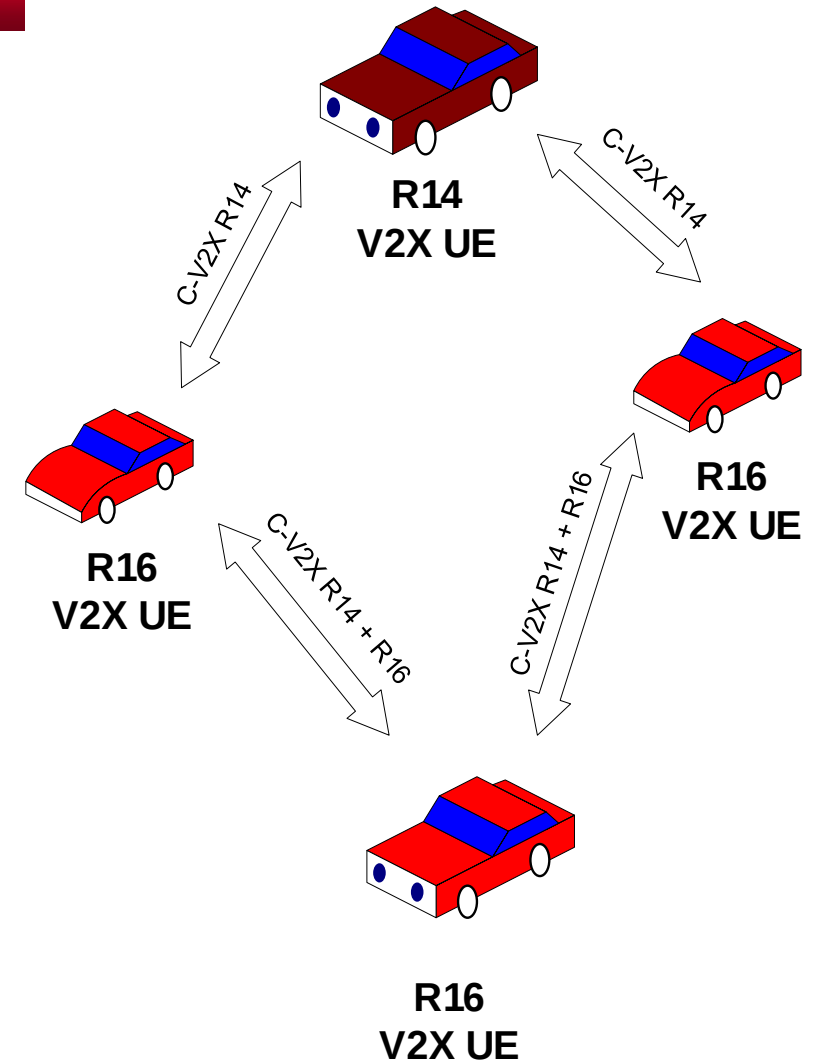
Spec	Title	Version
38.201	General Description	16.0.0
38.202	Services Provided by the Physical Layer	16.0.0
38.211	Physical Channels and Modulation	16.1.0
38.212	Multiplexing and Channel Coding	16.1.0
38.213	Physical Layer Procedures for Control	16.1.0
38.214	Physical Layer Procedures for Data	16.1.0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

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

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

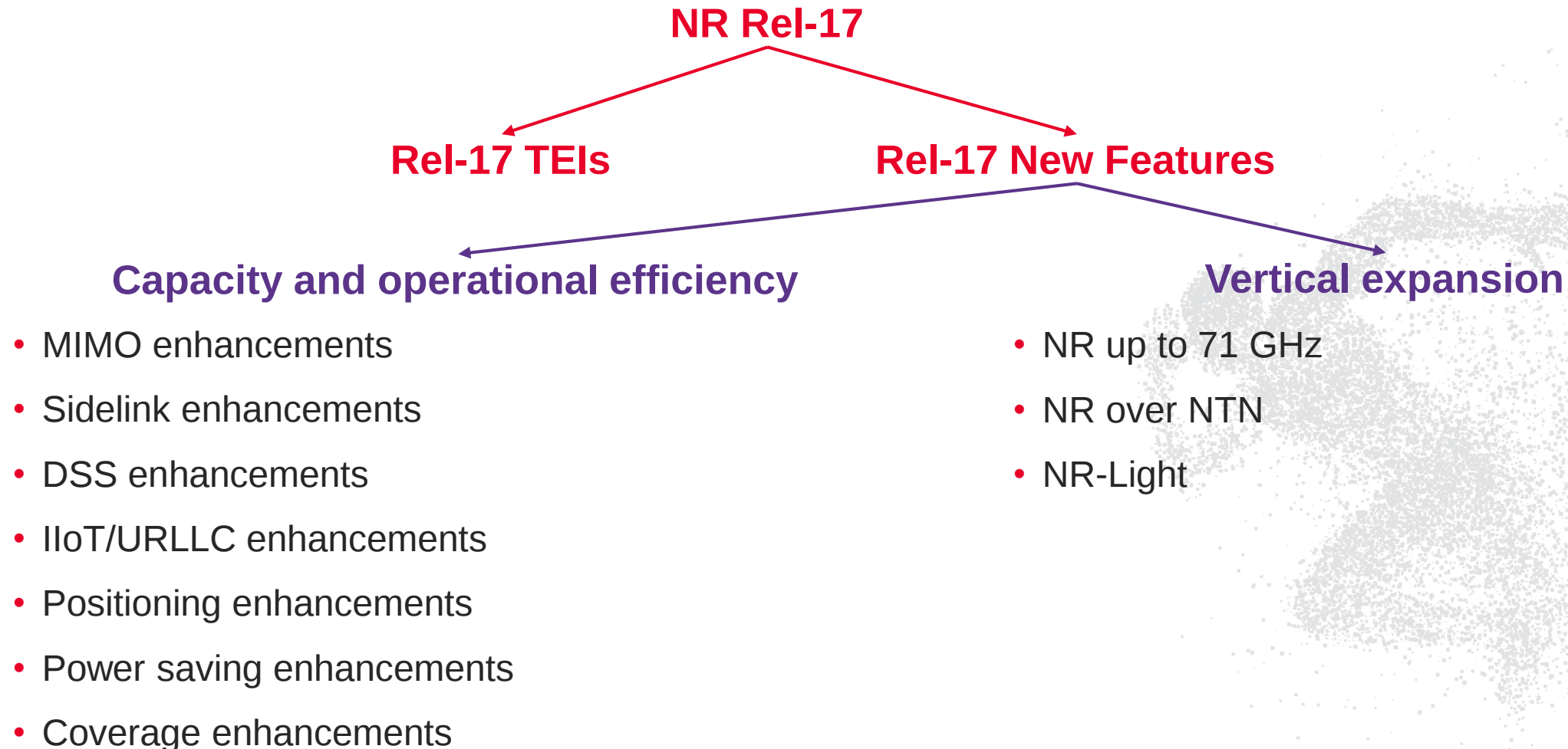


Introduction to NR Rel-17 (RAN1)



Rel-17 Content Summary

INTRODUCTION TO NR REL-17 (RAN1)



Rel-17 Workplan (RAN1)

INTRODUCTION TO NR REL-17 (RAN1)

 Study Item

 Work Item

2020			2021		SID WID
Q2	Q3	Q4	Q1	Q2	
	MIMO Enhancements				RP-193133
	Sidelink Enhancements				RP-193257
	NR up to 71 GHz	NR up to 71 GHz			RP-193259 RP-193229
	DSS Enhancements				RP-193260
	IIoT/URLLC Enhancements				RP-193233
			IOT over NTN		RP-193235
	NR over NTN				RP-193234
	Positioning Enhancements	Positioning Enhancements			RP-193237
	NR-Light	NR-Light			RP-193238
	Power Saving Enhancements				RP-193239
	Coverage Enhancements	Coverage Enhancements			RP-193240
		NR XR Study			RP-193241
			TEI-17		

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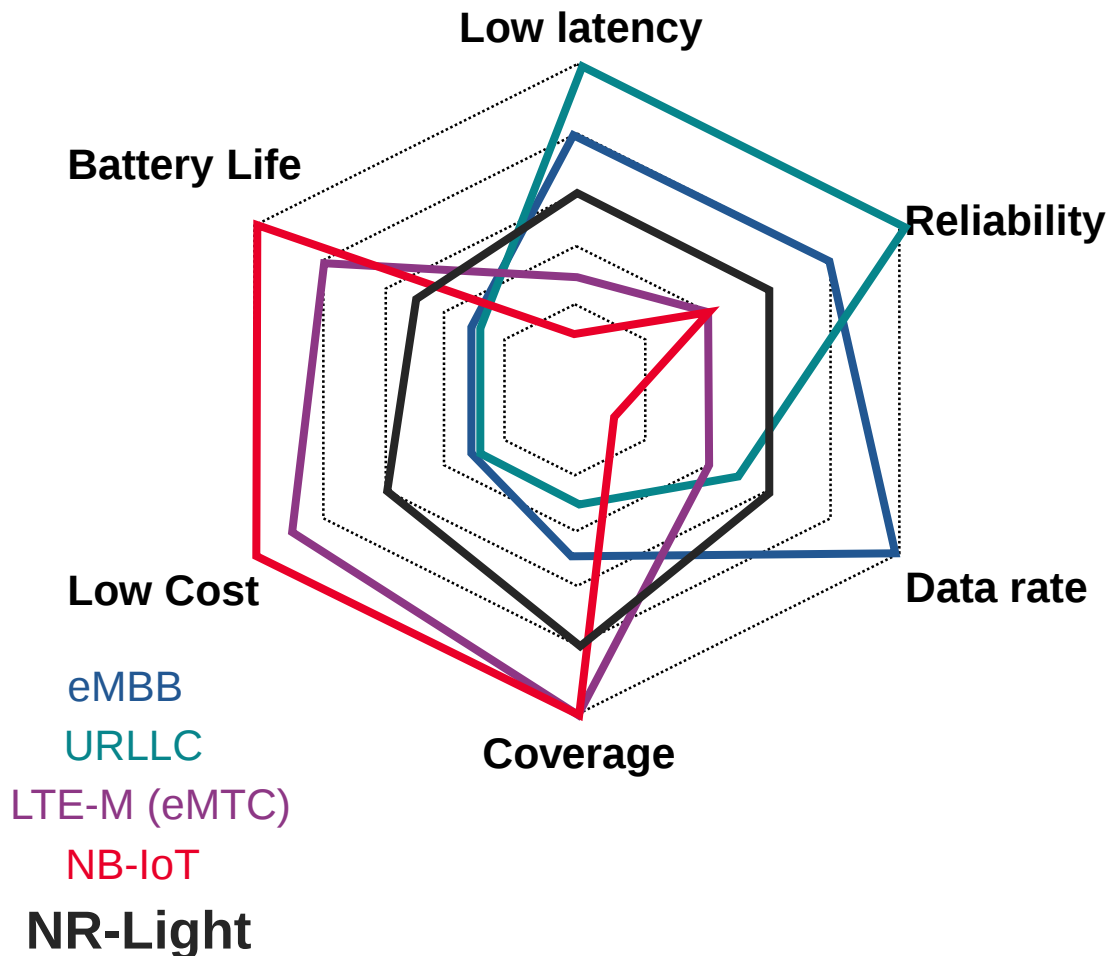
NR up to 71 GHz

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)

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

Non-Terrestrial Networks

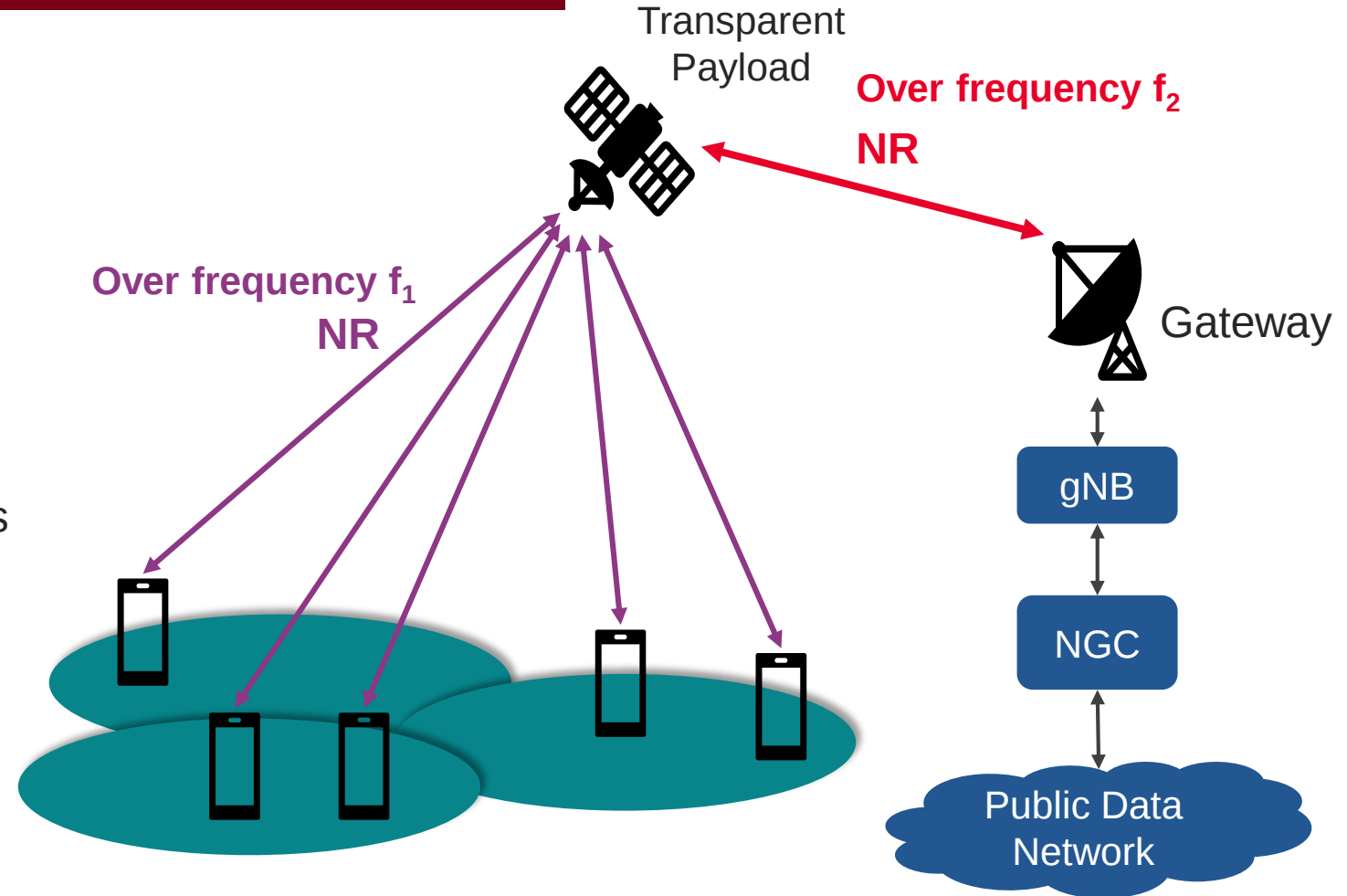
INTRODUCTION TO NR REL-17 (RAN1)

- **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)



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





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