



3GPP 5G Technology and Self Evaluation Results

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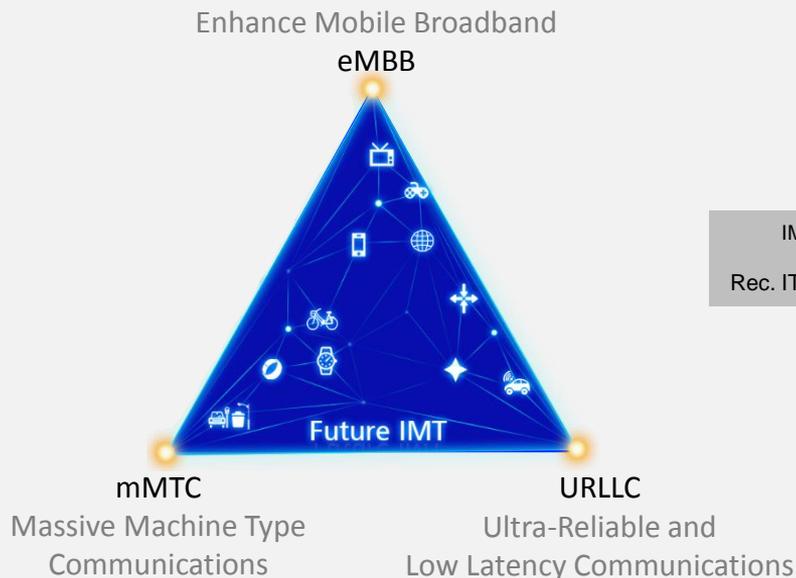
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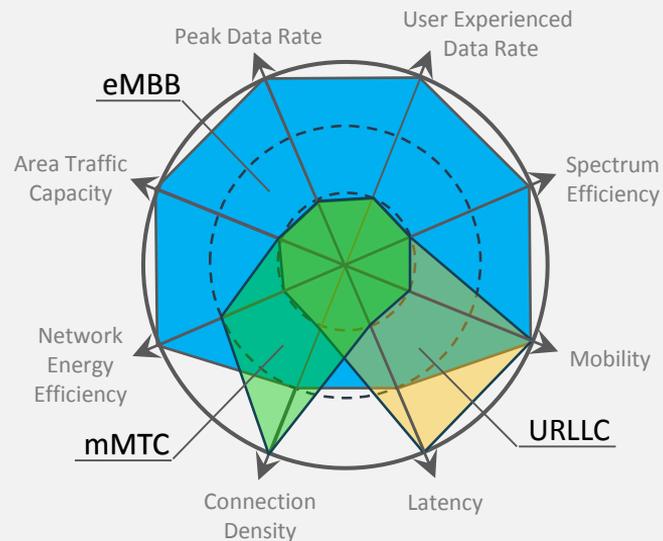
Conclusion

ITU-R IMT-2020 vision: Extend Radio to industries



IMT-2020 usage scenario

Diverse services

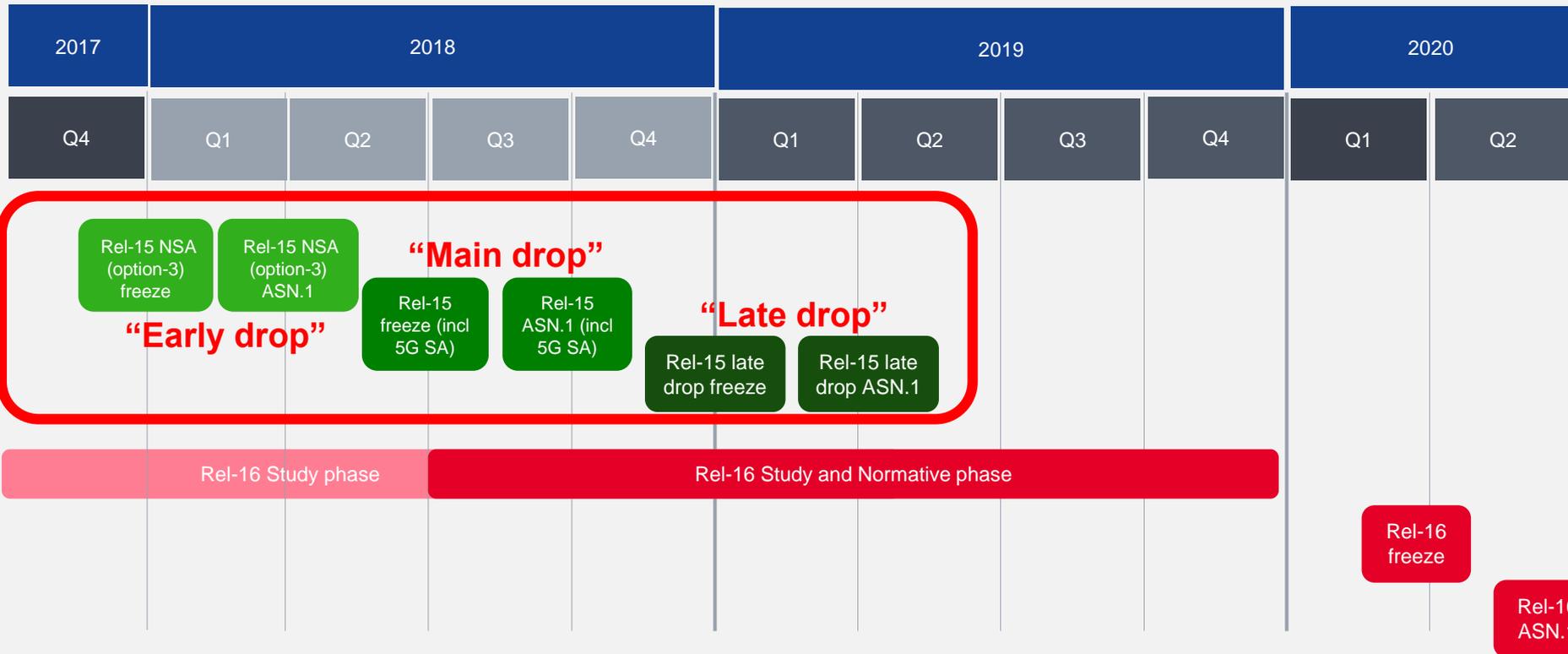


IMT-2020 Key capabilities

Diverse requirements

3GPP "5G" aims to meet ITU-R's IMT-2020 vision capabilities

3GPP 5G development timeline



3GPP 5G submission towards ITU-R

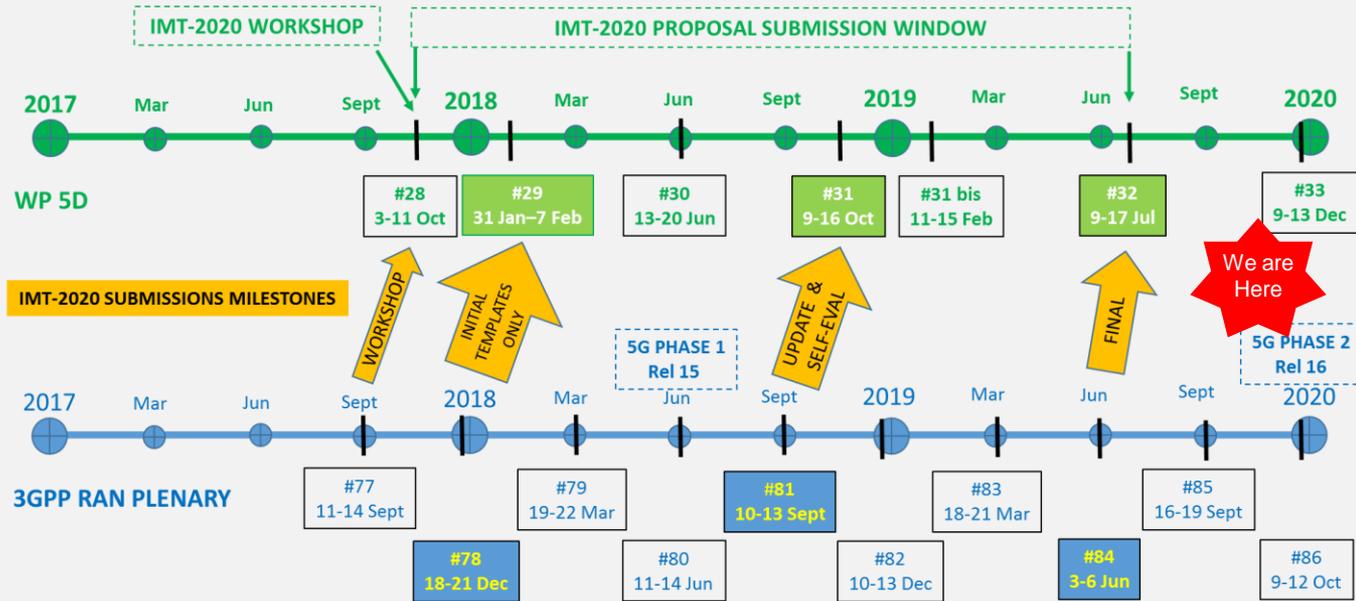
Name : 5G

Footnote: Developed by 3GPP as 5G, Release 15 and beyond

Submission 1: SRIT

- Component RIT: **NR**
- Component RIT: **EUTRA/LTE**
 - incl. standalone LTE, NB-IoT, eMTC, and LTE-NR DC
- full 38 and 36 series, and subset of 37 series

Submission 2: NR RIT



We are Here

3GPP provided complete submission templates to WP 5D#33 and acknowledgement is received.

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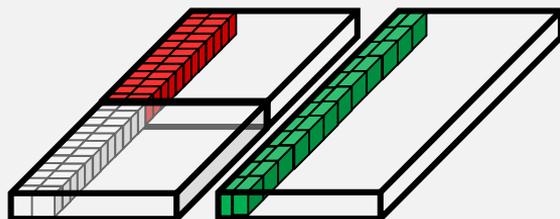
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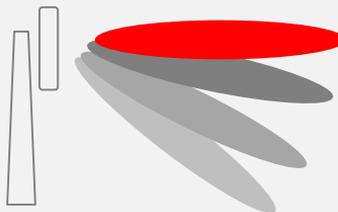
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3GPP 5G: NR key technical characteristics

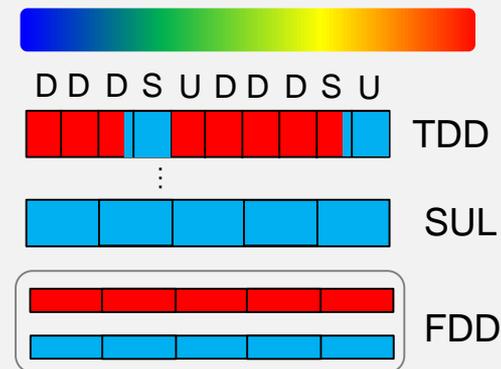
Flexible frame structure



Massive MIMO



Flexible spectrum utilization



Forward compatibility

- Minimize always-on transmissions
- Keep control channel together with data channel in frequency domain



- Avoid static/strict timing relations
- Reserved resources

3GPP 5G: NR flexible frame structure

Flexible Frame structure

- NR supports *reduced guard band ratio* with large component carrier bandwidth

SCS		Guard band ratio	
15kHz	10MHz BW: 6.4%	40 MHz BW: 2.8%	
30kHz	20 MHz BW: 8.2%	100 MHz BW: 1.7%	
60kHz	40 MHz BW: 8.2%	100 MHz BW: 2.8%	

- NR Multiple SCSs enable reduced slot durations

SCS (kHz)	Slot duration	SCS (kHz)	Slot duration
15	1ms	60	0.25ms
30	0.5ms	120	0.125ms

- NR PDSCH can reuse resources unused by NR PDCCH, saving large overhead especially in large bandwidth

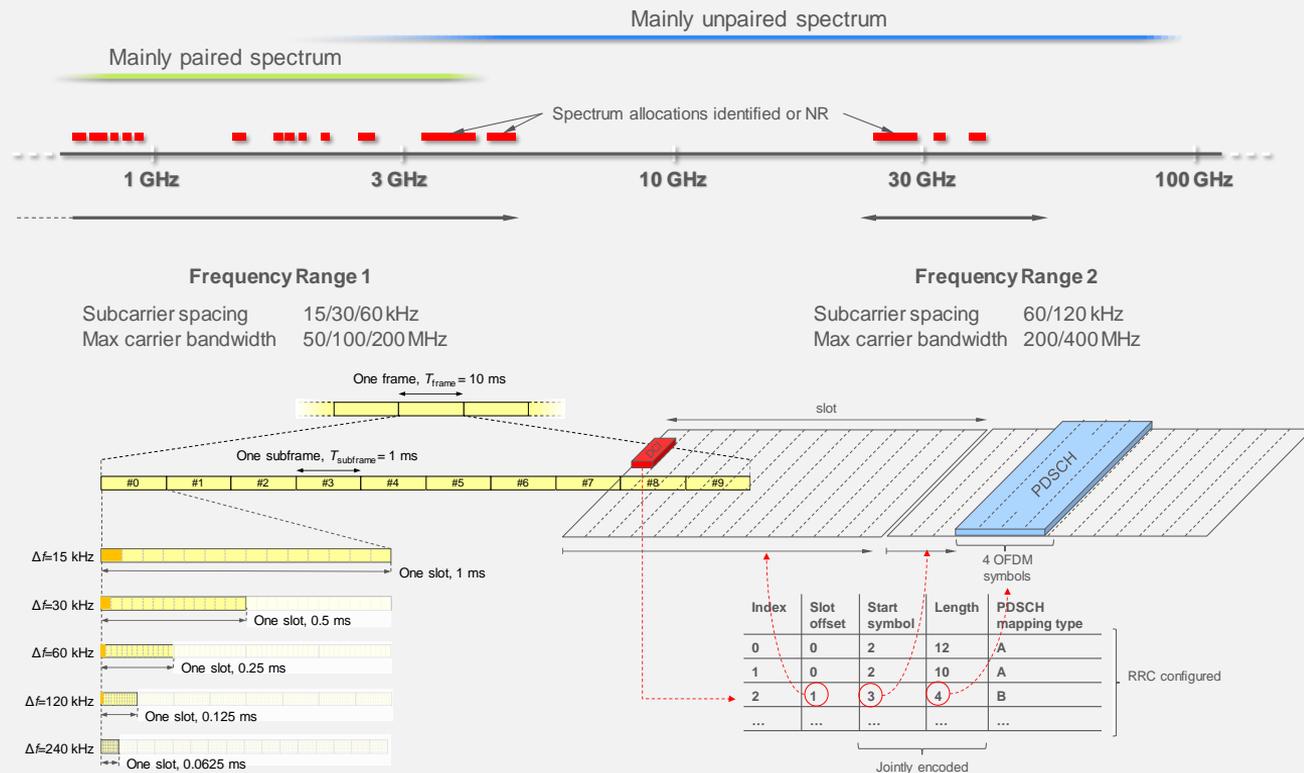
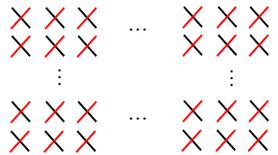


Figure source: RWS-180007, NR Physical Layer Design: Physical layer structure, numerology and frame structure, Havish Koorapaty, Ericsson

3GPP 5G: NR Massive MIMO

Massive MIMO

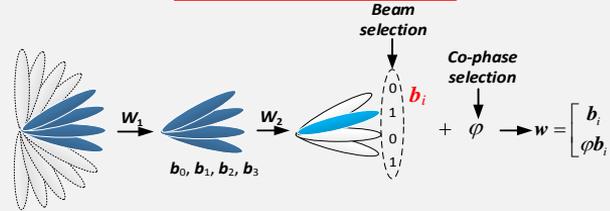
- NR supports up to 32 gNB ports codebook for FDD; and larger than 64 gNB ports for TDD



- NR Type I/II codebook

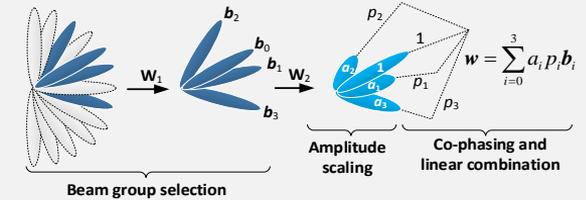
- NR supports 12 orthogonal DM-RS ports for MU pairing, as compared to 4 orthogonal UE specific RS ports in LTE
- NR overhead reduction for reference signals (RS): DMRS overhead reduction for DL/UL compared to LTE-A; no CRS.

NR Type-I codebook design



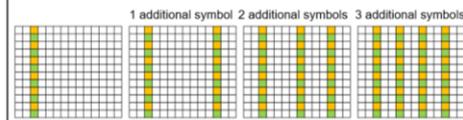
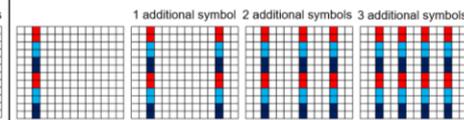
Terminal selects beam and co-phase (relative phase difference between X-pol antennas) coefficient

NR Type-II codebook design



Terminal selects multiple beams, amplitude scaling, and phase coefficients for linear combination between the beams

NR DM-RS design

	NR Type 1 DM-RS	NR Type 2 DM-RS
Orthogonal Ports	Up to 8	Up to 12
Flexibility	Can be adapted for frequency/time selectivity, robustness, number of co-scheduled UEs for MU-MIMO, etc	
Waveform	CP-OFDM (UL/DL) or DFT-S-OFDM (UL)	CP-OFDM only (UL/DL)
Design (figure for single symbol DM-RS)	IFDMA based 	Frequency domain orthogonal cover code based 
Overhead/Port	Higher	Lower

Source: RWS-180008, NR Physical Layer Design: NR MIMO, Younsun Kim, Samsung

3GPP 5G: NR flexible spectrum utilization

Flexible spectrum utilization

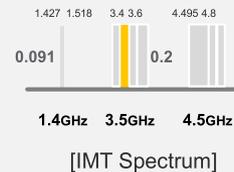
- NR supports up to 16 carrier aggregation and bandwidth part. Max BW of each carrier is 100 MHz (FR1) or 400 MHz (FR2).

	SCS [kHz]	Maximum aggregated bandwidth (MHz)
FR1	15	800
	30	1600
	60	1600
FR2	60	3200
	120	6400

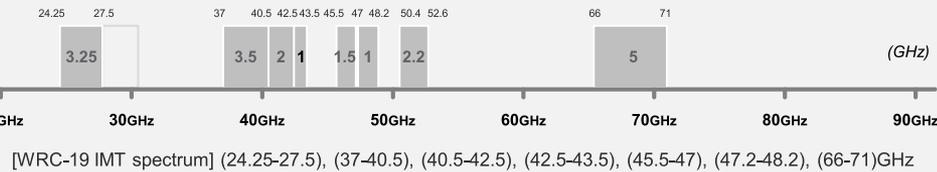
- NR supports FDD and semi-statically configuration of UL/DL split in TDD
- NR supports operating on a TDD band with supplementary uplink (SUL) band



FR1 (450MHz – 6GHz)



FR2 (24.25GHz – 52.6GHz)



Spectrum utilization for FR1

SCS (kHz)	5	10	15	20	25	30	40	50	60	70	80	90	100
	MHz												
	N_{RB}												
15	25	52	79	106	133	160	216	270	N.A	N.A	N.A	N.A	N.A
30	11	24	38	51	65	78	106	133	162	189	217	245	273
60	N.A	11	18	24	31	38	51	65	79	93	107	121	135

Source: RWS-180011, NR Radio Frequency and co-existence, Xutao Zhou, Samsung

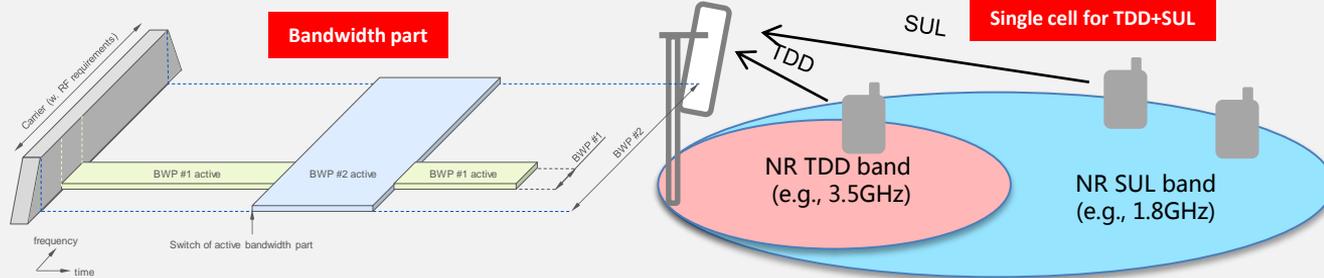
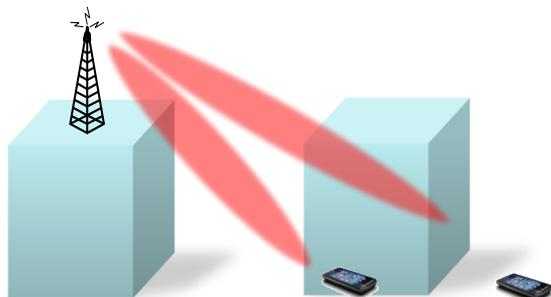


Figure source: RWS-180007, NR Physical Layer Design: Physical layer structure, numerology and frame structure, Havish Koorapaty, Ericsson

Figure source: RWS-180018, Self evaluation: Enhanced Mobile Broadband (eMBB) Evaluation results, Wu Yong, Huawei

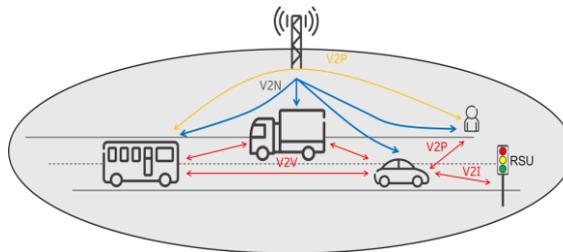
3GPP 5G: LTE evolution

Elevation Beamforming/ Full-Dimension MIMO



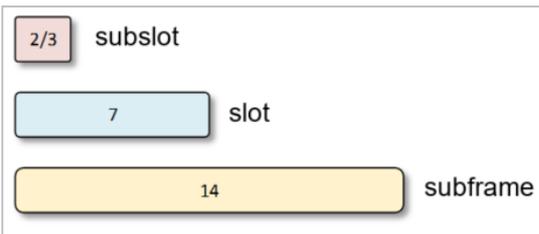
- Increased number CSI-RS ports to 12 and 16
- Beam selection
- SRS enhancements for low delay spread channels
- DMRS enhancements to increase the number of co-scheduled UEs

Proximity services (ProSe) and vehicle-to-everything (V2X)



- UE-autonomous and NW-managed resource allocation for sidelink
- Distributed synchronization for no network coverage
- New physical layer format for high mobility scenarios (V2X)
- New cellular multicast periodicities for reduced latency

Shortened TTI and processing time



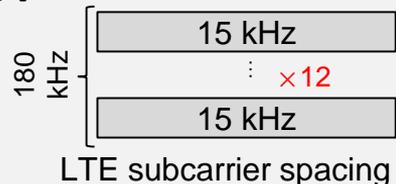
- Shortened TTI and processing time for LTE, possibility for subslot- (2 or 3 symbols long) and slot-based transmission.
- A shortened processing time of $n+3$ (compared to $n+4$) for subframe-based transmissions

3GPP 5G: NB-IoT and eMTC

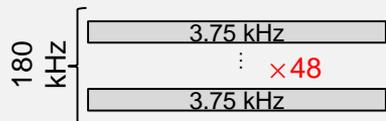
NB-IoT



Single-tone and 3/6/12-tone UL allocations

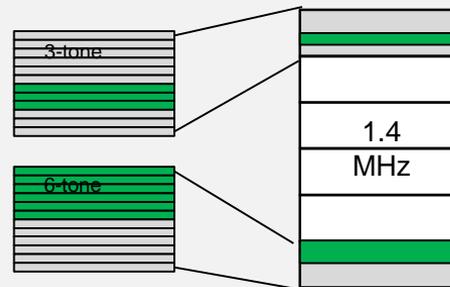


LTE subcarrier spacing

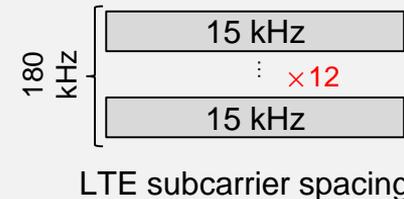


Dense subcarrier spacing

eMTC



3- and 6-tone allocations within a PRB of a 1.4 MHz bandwidth



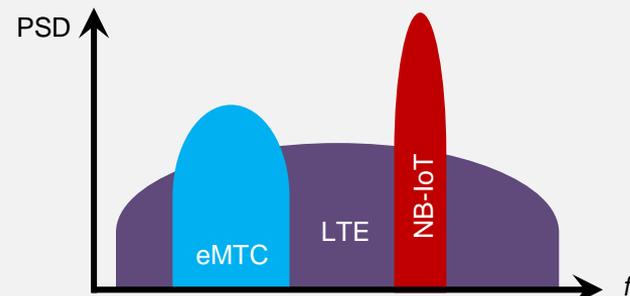
LTE subcarrier spacing



Non-anchor carriers for capacity and load-balancing



Source: RWS-180023, 3GPP's Low-Power Wide-Area IoT Solutions: NB-IoT and eMTC, Matthew Webb, Huawei

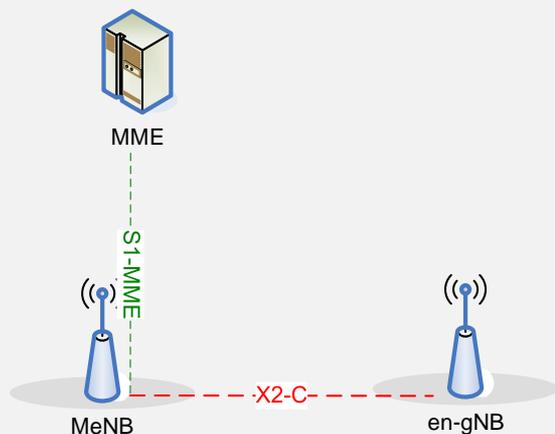


PSD boost in bandwidth as small as 3.75 kHz

3GPP 5G architecture

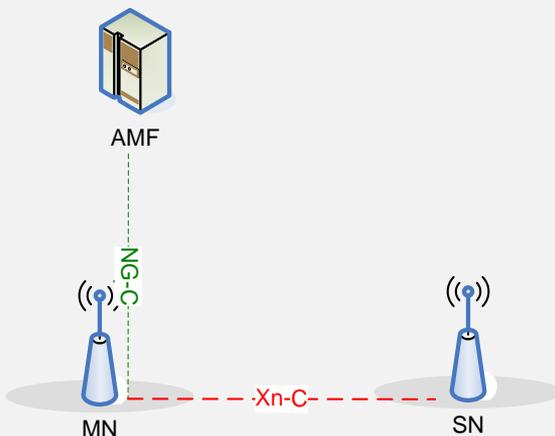
Option 3 “EN-DC”

- “LTE eNB” as Master Node (MN), connected to *LTE core network*
- “NR gNB” as Secondary Node (SN)



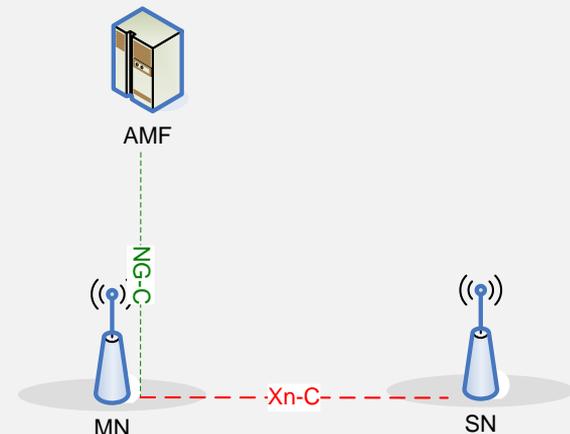
Option 2 NR Standalone; NR-NR DC Option 4 “NE-DC”

- “NR gNB” as MN, connected to *5G core network*
- “NR gNB” or “LTE eNB” as SN



Option 5 LTE to 5GC Option 7 “NGEN-DC”

- “LTE eNB” as MN, connected to *5G core network*
- “NR gNB” as SN



Source: RWS-180009, NR Architecture, Gino Masini, Ericsson

3GPP provided multiple options for smooth migration to 5G based on operator’s strategies.

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3GPP submission templates

According to Report ITU-R M.2411 “Requirements, Evaluation criteria, and submission templates for the development of IMT-2020”. 3GPP provided the following submission templates and preliminary self evaluation

Description templates

Characteristics templates

- For SRIT (NR+LTE)
- For NR RIT



Link budget template

- NR in 5 test environments,
- LTE in 4 test environments

Compliance templates

Compliance templates

- For SRIT (NR+LTE)
- For NR RIT

On

- ✓ Service, Spectrum and Technical performance requirement

Self evaluation report TR37.910v16.1.0

- Based on evaluation guidelines defined in Report ITU-R M.2412.
- **Evaluation results for Rel-15/16**
 - ✓ **NR RIT:** 5 test environments for eMBB, URLLC and mMTC
 - ✓ **LTE RIT:** Indoor/Dense Urban/Rural – eMBB and Urban Macro – mMTC



IMT-2020 submission

3GPP Submission Templates Description templates - Characteristics



Characteristics template for 3GPP 5G SRIT (Release 15 and beyond)

The description templates provided by 3GPP are for the description of the characteristics of 5G¹ developed by 3GPP. It includes one characteristics template for SRIT (encompassing NR and LTE), and one characteristics template for NR RIT.

This document provides the characteristics template for the description of the characteristics of the SRIT which consists of two component RITs "NR" and "LTE", based on 3GPP Rel-15 and Rel-16 work.

For this characteristics template, 3GPP has addressed all of the characteristics, and it is expected that these descriptions are helpful to assist in evaluation activities for independent evaluation groups, as well as to facilitate the understanding of the state-of-art of 3GPP development on the RIT.

Characteristics template for 3GPP 5G NR RIT (Release 15 and beyond)

The description templates provided by 3GPP are for the description of the characteristics of 5G¹ developed by 3GPP. It includes one characteristics template for SRIT (encompassing NR and LTE), and one characteristics template for NR RIT.

This document provides the characteristics template for the description of the characteristics of the NR RIT based on 3GPP Rel-15 and Rel-16 work.

For this characteristics template, 3GPP has addressed all of the characteristics, and it is expected that these descriptions are helpful to assist in evaluation activities for independent evaluation groups, as well as to facilitate the understanding of the state-of-art of 3GPP development on the RIT.

Item	Item to be described
5.2.3.2.1	Test environment(s)
5.2.3.2.1.1	What test environments (described in Report ITU-R M.2412-0) does this technology description template address? <i>This proposal targets to addresses all the five test environments across the three usage scenarios (eMBB, mMTC, and URLLC) as described in Report ITU-R M.2412-0.</i>
5.2.3.2.2	Radio interface functional aspects
5.2.3.2.2.1	<i>Multiple access schemes</i> Which access scheme(s) does the proposal use? Describe in detail the multiple access schemes employed with their main parameters. - Downlink and Uplink: <i>The multiple access is a combination of</i> <ul style="list-style-type: none"> OFDMA: Synchronous/scheduling-based, the transmission to/from different UEs uses mutually orthogonal frequency assignments. Granularity in frequency assignment: One resource block consisting of 12 subcarriers. Multiple sub-carrier spacings are supported including 15kHz, 30kHz, 60kHz and 120kHz for data (see Item 5.2.3.2.7 and reference therein).

- 3GPP provided characteristics description for SRIT (NR+LTE) and NR RIT for all items.
- The description on new and key functionalities are the basis for ITU evaluation.

- Test environment(s)
- Radio interface functional aspects (multiple access, modulation, PAPR, coding scheme)
- Channel tracking capabilities (e.g., pilot symbol configuration)
- Physical channel structure and multiplexing
- Mobility management (Handover)
- Radio resource management
- Frame structure
- Spectrum capabilities and duplex technologies
- Support of Advanced antenna capabilities
- Link adaptation and power control
- Power classes
- Scheduler, QoS support and management, data services
- Radio interface architecture and protocol stack
- Cell selection
- Location determination mechanisms
- Priority access mechanisms
- Unicast, multicast and broadcast
- Privacy, authorization, encryption, authentication and legal intercept schemes
- Frequency planning
- Interference mitigation within radio interface
- Synchronization requirements
- Support for wide range of services
- Global circulation of terminals
- Energy efficiency
- Other items © 3GPP 2019

Characteristics Description: More references



The Mobile
Broadband Standard



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3GPP 5G – Briefing for Evaluation Groups

October 27, 2018

This week's 3GPP Workshop on 5G NR, hosted by the European Commission, has been a comprehensive briefing from the key experts in 3GPP for the benefit of the official Independent Evaluation Groups (IEGs), who's job it will be to report to the International Telecommunications Union (ITU) on whether the 3GPP system for 5G meets the performance requirements (in ITU-R M.2412) for an IMT-2020 technology.

IMT stands for International Mobile Telecommunications, the term is used by the ITU to describe generations of radio interface standards for mobile systems. The latest member of the IMT family is IMT-2020 which calls for support for enhanced mobile broadband (eMBB) and for new 'use cases' that require massive machine-type communications (mMTC) and ultra-reliable and low latency communications (URLLC).

These objectives reflect perfectly 5G research project's pre-standards work and also the priorities for 3GPP work from Release 15 onwards. It is a little bit of 'chicken and egg' in terms of which came first, but the alignment between IMT-2020, 5G R&D and the 3GPP work plan is an important achievement, which will help greatly at the World Radiocommunication Conference 2019, where deliberations on additional spectrum in support of IMT will take place.

In closing the 3GPP Workshop, Balazs Berternyik concluded that - based on the results presented - there is a high level of confidence in the community that 3GPP's submission to IMT-2020 will meet the ITU requirements. He asked all of the Independent Evaluation Groups to contact the 3GPP leadership and experts directly at any time in the process, to build on the dialogue started in Brussels this week.

The presentations below are provided for your information. They include the latest versions of the IMT-2020 submission templates and the latest 3GPP self evaluation results:

Document

[RWS-180004](#)

The 3GPP Submission

[RWS-180005](#)

Overview of RAN aspects

[RWS-180006](#)

System and Core Network Aspects

[RWS-180007](#)

NR Physical Layer Design: Physical layer structure, numerology and frame structure

[RWS-180008](#)

NR Physical Layer Design: NR MIMO

[RWS-180009](#)

NR Architecture

[RWS-180010](#)

NR Radio interface Protocols

[RWS-180011](#)

NR Radio Frequency and co-existence

[RWS-180023](#)

3GPP's Low-Power Wide-Area IoT Solutions: NB-IoT and eMTC

[RWS-180013](#)

LTE evolution

Search

3GPP Website: Search for...

Search and download specs, docs, CRs and more from the 3GPP FTP Server:

ADVANCED FTP SEARCH

More News:

- Webinar on RAN Rel-16 progress and Rel-17 work area discussions
- 3GPP SA6 work on new verticals
- TV and radio services over 3GPP systems
- 5G for Control Applications in Vertical Domains

Self evaluation report TR 37.910

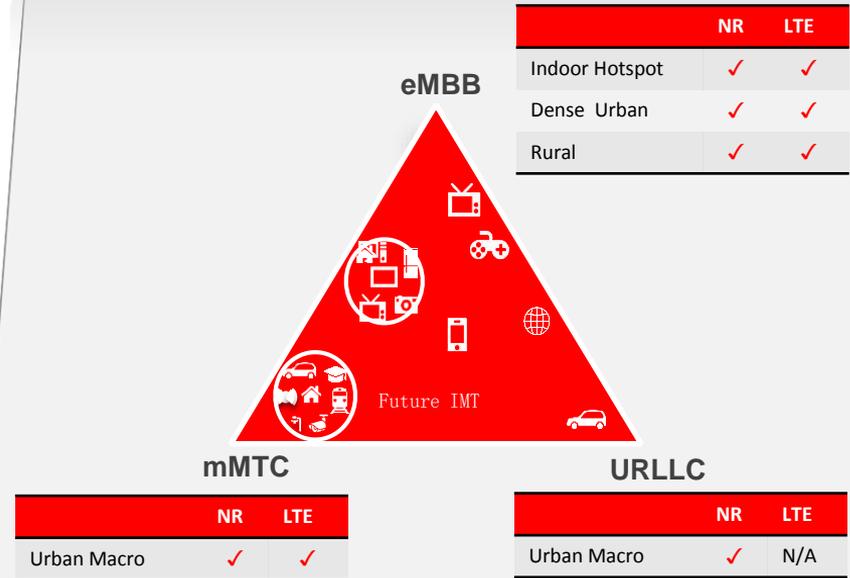
3GPP TR 37.910 v16.1.0 (2019-09)
Technical Report

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Study on self evaluation towards IMT-2020 submission
(Release 16)

5G

3GPP
A GLOBAL INITIATIVE

- TR 37.910 v16.1.0 provides the full assessment of 3GPP 5G towards IMT-2020 requirements



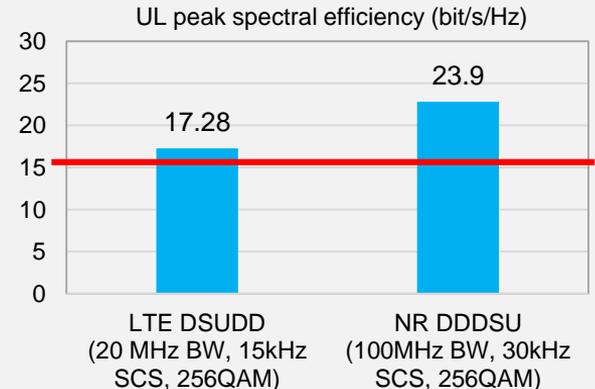
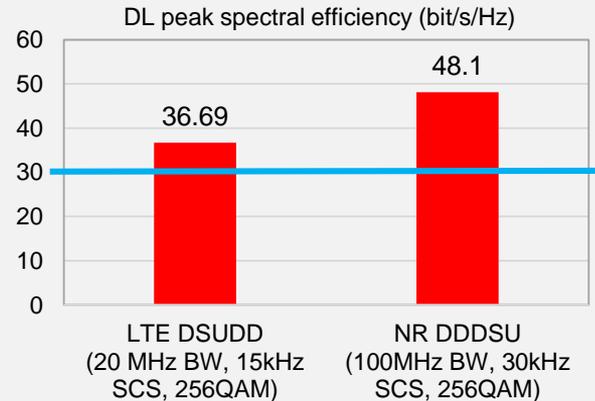
Peak spectral efficiency

- **Peak spectral efficiency:**

- DL: 8 layer for FR1; 6 layer for FR2; 256QAM (NR, LTE) / 1024QAM (LTE), max code rate = 0.9258 (NR) / 0.93 (LTE)
- UL: 4 layer, 256QAM, max code rate = 0.9258 (NR) / 0.93 (LTE)

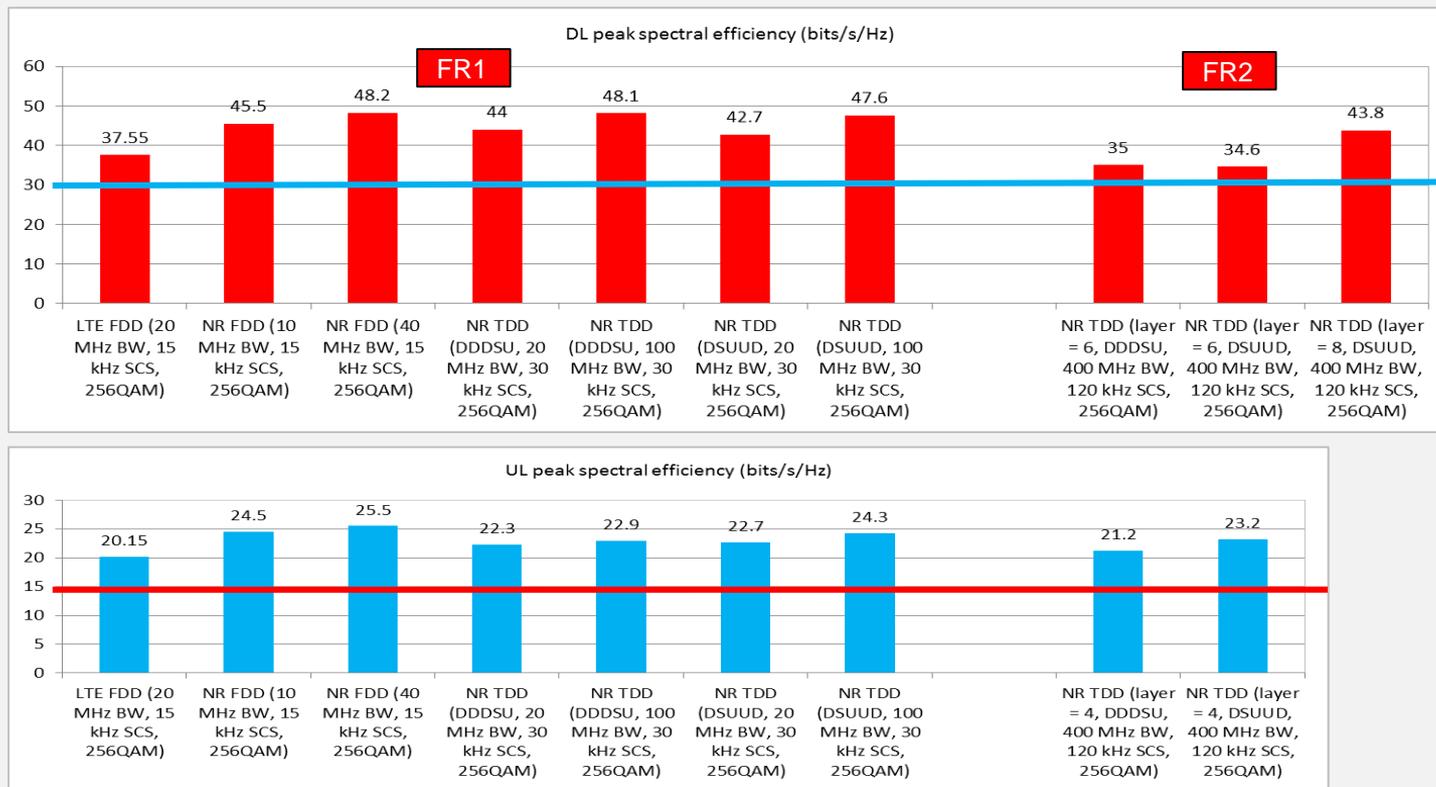
- **Contributing technical components:**

- NR large CC bandwidth introduces reduced guard band ratio
- NR small overhead for DL:
 - ✓ For PDCCH, as low as 0.6% @ 100 MHz for low load; 8-layer DMRS overhead reduced to 9.5%; no CRS
- NR small overhead for UL:
 - ✓ 4-layer DMRS overhead reduced to 7% under UL OFDMA; “Special subframe” can be used to transmit UL data -> Overhead reduced.
- ...



Peak spectral efficiency

- Various NR/LTE configurations are evaluated; see Section 5.1 of TR37.910 for details.



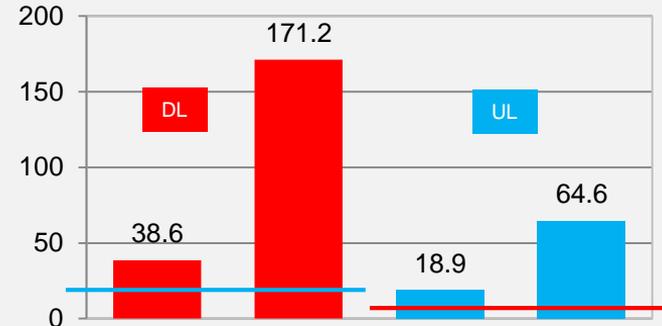
Peak data rate

- Peak data rate:

$$\text{Peak data rate} = (\text{Peak SE}) \times (\text{Aggregated bandwidth})$$

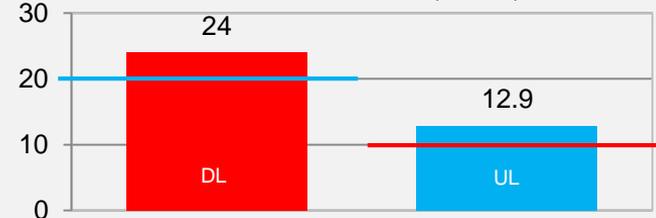
- NR Max aggregated bandwidth :
 - ✓ FR1 (15 kHz SCS): 16 CC x 50 MHz/CC = **800 MHz**
 - ✓ FR1 (30/60 kHz SCS): 16 CC x 100 MHz/CC = **1.6 GHz**
 - ✓ FR2 (120 kHz SCS): 16 CC x 400 MHz/CC = **6.4 GHz**
- LTE Max aggregated bandwidth:
 - ✓ 32 CC x 20 MHz/CC = **640 MHz**

NR Peak data rate (Gbit/s)



- For various NR configurations

LTE Peak data rate (Gbit/s)



- For LTE FDD (256QAM) with 640 MHz BW

Average and 5th percentile user SE

- Contributing technical components for DL:

- *NR frame structure:*

- ✓ NR large CC bandwidth introduces reduced guard band ratio
- ✓ NR PDCCH and PDSCH sharing allows overhead reduction, especially in large CC bandwidth

- *NR Massive MIMO:*

- ✓ NR Type II codebook and 12 orthogonal DMRS enhances MU-MIMO spectral efficiency especially for FDD
- ✓ NR fast CSI feedback and SRS capacity enhancement improves MU-MIMO spectral efficiency especially for TDD.

-

- Contributing technical components for UL:

- NR large CC bandwidth introduces reduced guard band ratio
- NR DMRS overhead reduction for UL OFDMA compared to LTE-A
- NR SRS capacity enhancement accelerates UL CSI derivation
- NR OFDMA enables flexible and efficient resource allocation

-

2 OS for 10MHz

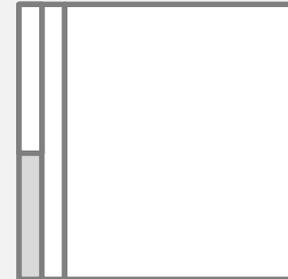


- NR PDCCH overhead reduction for large bandwidth

1 OS for 20MHz

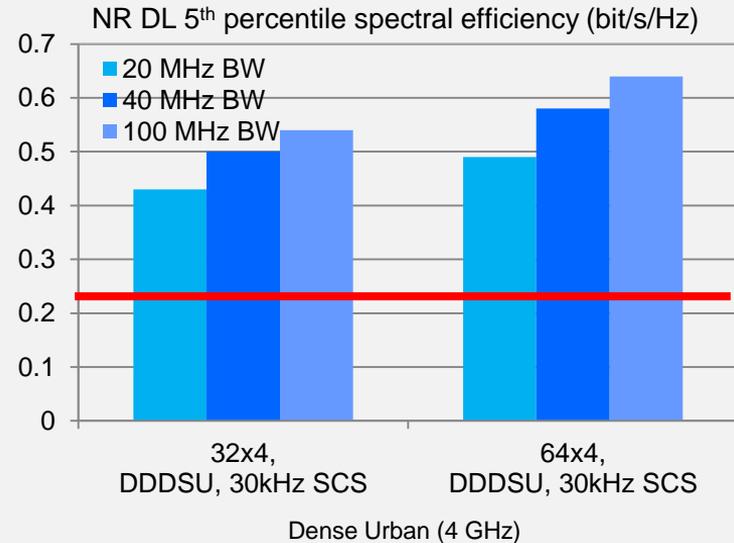
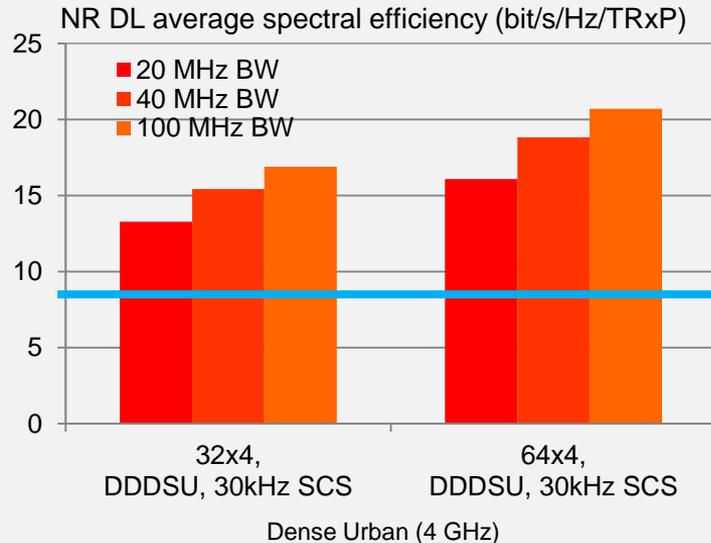


0.5 OS for 40MHz



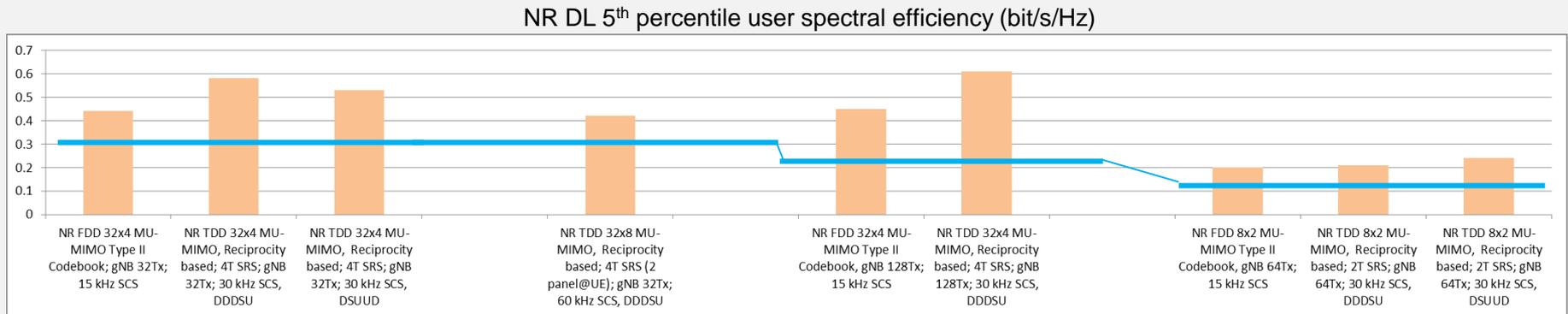
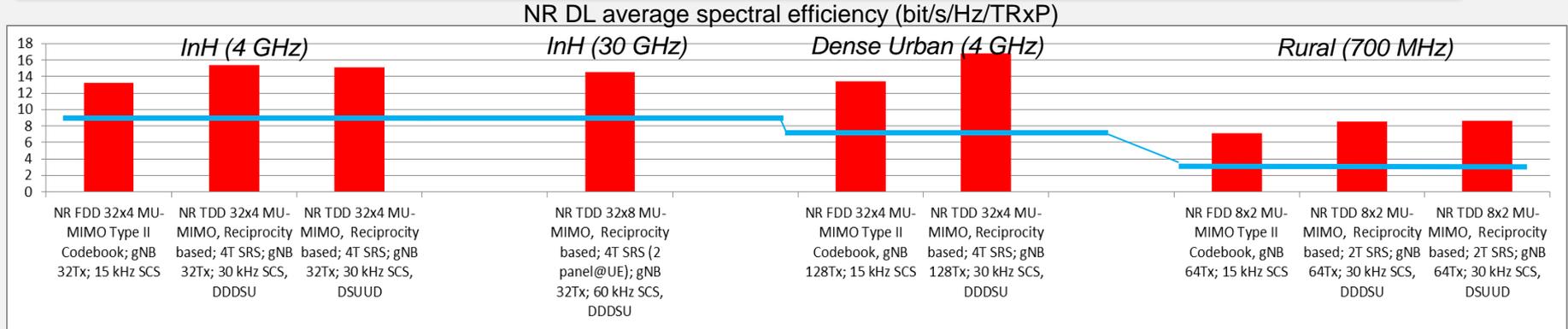
Average and 5th percentile user SE

- NR evaluation results for Dense Urban:
 - Larger CC bandwidth brings improved SE (~30%) due to guard band ratio reduction and PDCCH overhead reduction
 - NR Massive MIMO: 64 TXRU brings additional gain over 32 TXRU in TDD.



Average and 5th percentile user SE

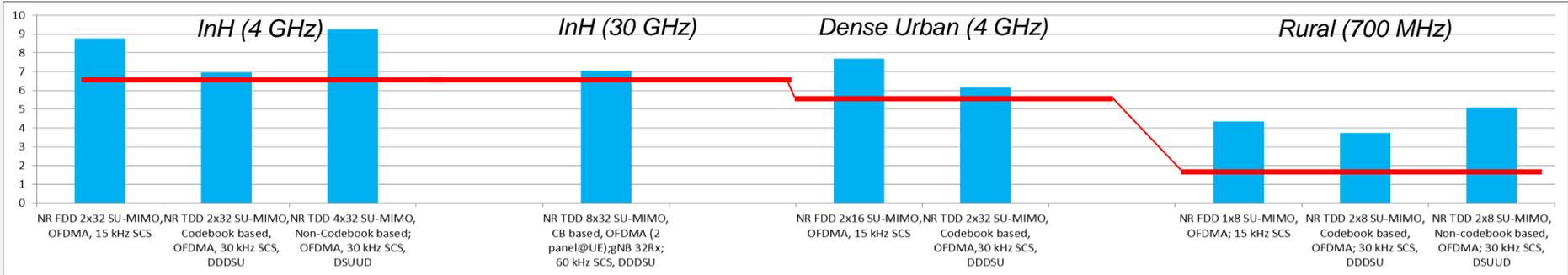
- Various NR configurations are evaluated. See Section 5.4 of TR37.910 for details



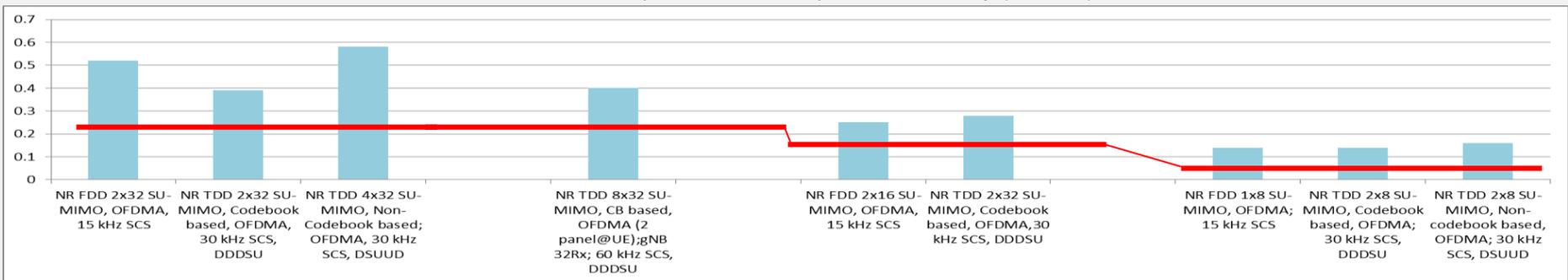
Average and 5th percentile user SE

- Various NR configurations are evaluated. See Section 5.4 of TR37.910 for details

NR UL average spectral efficiency (bit/s/Hz/TRxP)



NR UL 5th percentile user spectral efficiency (bit/s/Hz)

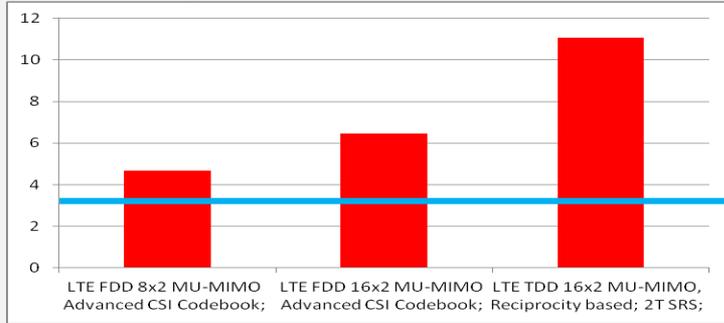


Average and 5th percentile user SE

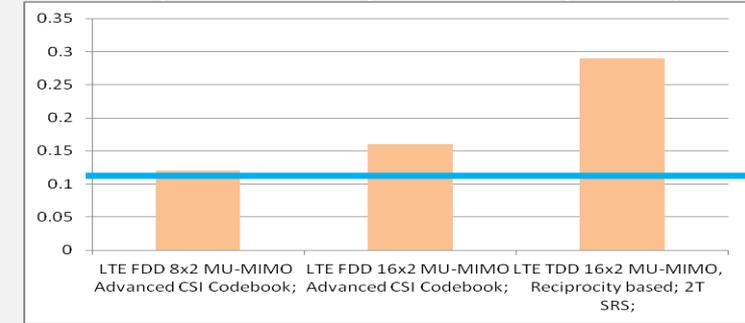
- Various LTE configurations are evaluated for Rural, Indoor and Dense Urban - eMBB. See Section 5.4 of TR37.910 for details

DL

LTE DL average spectral efficiency, Rural (bit/s/Hz/TRxP)

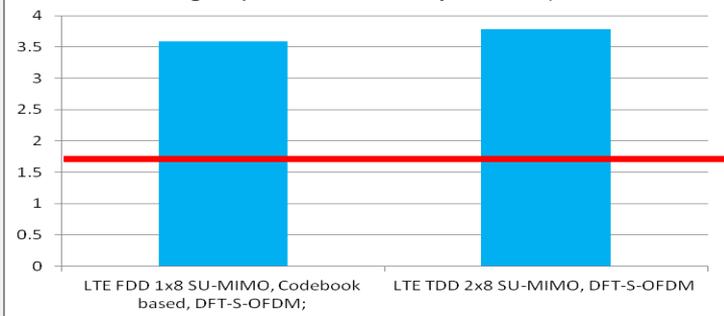


LTE DL 5th percentile user spectral efficiency, Rural (bit/s/Hz)

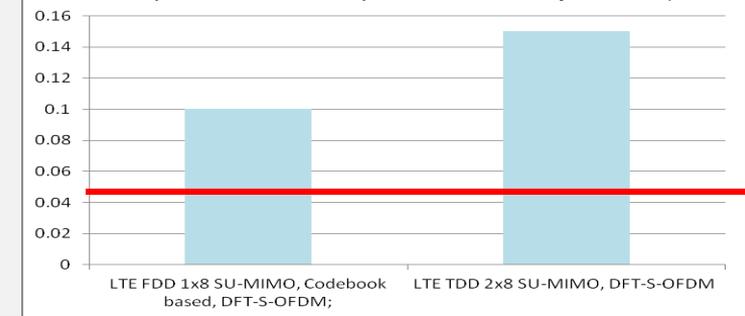


UL

LTE UL average spectral efficiency, Rural (bit/s/Hz/TRxP)



LTE UL 5th percentile user spectral efficiency, Rural (bit/s/Hz)



User experienced data rate

● Contributing technical components :

- For both DL and UL, carrier aggregation can be used to boost the user experienced data rate.
- For the case of where NR TDD band is in higher frequency range, TDD+SUL can benefit UL user experienced data rate :
 - ✓ *Usually TDD band is in higher frequency range than SUL band.*
 - ✓ *In this case, cell edge users can be allocated to SUL band for uplink transmission where lower propagation loss is observed.*
-

Required bandwidth
for user experienced data rate (Dense Urban)

Target	Band	Required BW
DL target = 100 Mbit/s	4 GHz (NR FDD/TDD; various antenna configuration)	160~560 MHz BW
UL target = 50 Mbit/s	4 GHz (NF FDD/TDD; various antenna configuration)	120 ~ 800 MHz BW
	30 GHz (NR TDD, 8x32) + 4 GHz (SUL, 2x32)	30 GHz: 1.2 GHz BW; 4 GHz: 100 MHz BW

NR fulfills user experienced data rate requirement with its supported bandwidth capability.

Area traffic capacity

- Area traffic capacity:

$$\text{Area traffic capacity} = \frac{(\text{Average SE}) \times (\text{Aggregated bandwidth})}{(\text{Simulation area})}$$

- NR Max aggregated bandwidth :

- ✓ FR1 (15 kHz SCS): 16 CC x 50 MHz/CC = **800 MHz**
- ✓ FR1 (30/60 kHz SCS): 16 CC x 100 MHz/CC = **1.6 GHz**
- ✓ FR2 (120 kHz SCS): 16 CC x 400 MHz/CC = **6.4 GHz**

Required bandwidth
for area traffic capacity (Indoor hotspot)

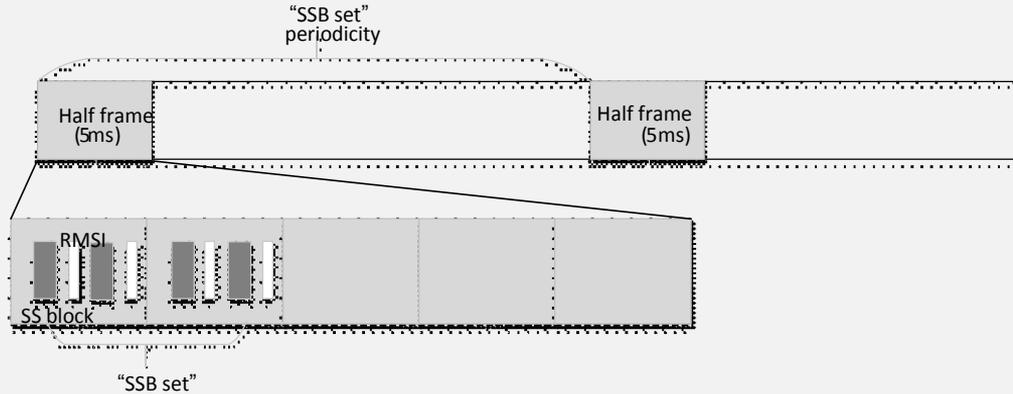
Frequency band	Required BW for DL target of 10 Mbit/s/m ²	
	12TRxP	36TRxP
4 GHz	360 MHz ~ 800 MHz	120 MHz ~ 280 MHz
30 GHz	600 MHz ~ 1200 MHz	200 MHz ~ 400 MHz

NR fulfills area traffic capacity requirement with its supported bandwidth capability.

Energy efficiency

- Network energy efficiency

- Related to always-on transmissions; For NR, SSB period can be configured as long as 160ms



NR gNB sleep ratio under low load

SSB configuration		SSB set periodicity
SCS [kHz]	Number of SS/PBCH block per SSB set, L	P_{SSB} 160ms
15kHz	1	99.38%
	2	99.38%
30kHz	1	99.84%
	4	99.38%
120kHz	8	99.69%
	16	99.38%
240kHz	16	99.69%
	32	99.38%

- Device energy efficiency

- Discontinuous reception (DRX)
- BWP adaptation for NR
- RRC_INACTIVE state for NR

NR Device sleep ratio for idle / in-active mode

	Paging cycle $N_{PC,RF} * 10$ (ms)	SCS (kHz)	SSB L	SSB reception time(ms)	SSB cycle (ms)	Number of SSB burst set	RRM measurement time per DRX (ms)	Transition time(ms)	Sleep ratio
RRC-Idle/Inactive	320	240	32	1	--	1	3.5	10	95.5%
	2560	15	2	1	--	1	3	10	99.5%
	2560	15	2	1	160	2	3	10	93.2%

NR fulfills energy efficiency requirement.

Energy efficiency

- Network energy efficiency
 - For LTE, FeMBMS/Unicast-mixed cell and MBMS-dedicated cell can switch off the always-on signals.

LTE eNB sleep ratio under low load

Cell type	Sleep ratio
FeMBMS/Unicast-mixed cell	80%
MBMS-dedicated cell	93.75%

- Device energy efficiency
 - Discontinuous reception (DRX)

LTE Device sleep ratio under idle mode

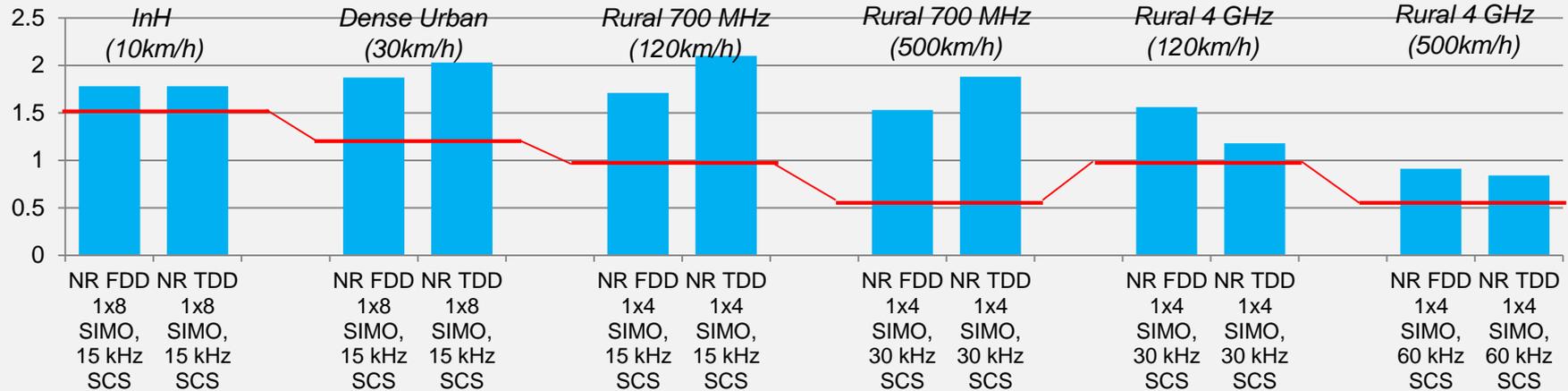
	Paging cycle $N_{PC_RF} * 10$ (ms)	Synchronization reception time per cycle(ms)	Synchroniza tion cycle(ms)	Number of synchronization	RRM measurement time per DRX (ms)	Transition time (ms)	DL/UL subframe ratio	Sleep ratio
RRC-Idle	320	2	10*	1	6	10	1	93.1%
	320	2	10*	2	6	10	1	90.0%
	2560	2	10*	1	6	10	1	99.1%
	2560	2	10*	2	6	10	1	98.8%

LTE fulfills energy efficiency requirement.

Mobility

- Mobility is evaluated using MIMO configurations.
- Contributing technical components:
 - *NR frame structure:*
 - ✓ NR multiple SCSs allow to use larger sub-carrier spacing which is beneficial to combat with Doppler spread.
 - ✓ NR fast CSI feedback and low processing delay helps to combat with time variation of propagation channel.

NR Mobility: Normalized traffic channel link data rate (bit/s/Hz)
 (Some example configurations; see Section 5.9 of TR37.910 for more details)



User plane latency

- Contributing technical components for NR:

- *NR frame structure:*

- ✓ NR larger SCSs allow slot duration reduction.
- ✓ NR non-slot allows to use less number of OFDM symbol for data transmission, also beneficial to reduce air-interface transmission duration
- ✓ Resource mapping type B allows immediate data transmission once scheduling resource is available.

- *NR Flexible configuration of DL/UL slot:*

- ✓ beneficial to reduce DL or UL waiting time

- *NR TDD+SUL:*

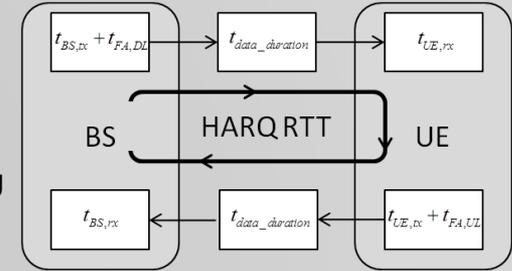
- ✓ SUL provided continuous uplink transmission opportunity to reduce DL ACK feedback and UL waiting time.
- ✓ This is especially useful for synchronized network with DL dominant configurations (e.g., DDDSU).

-

- Contributing technical components for LTE:

- *Short TTI*

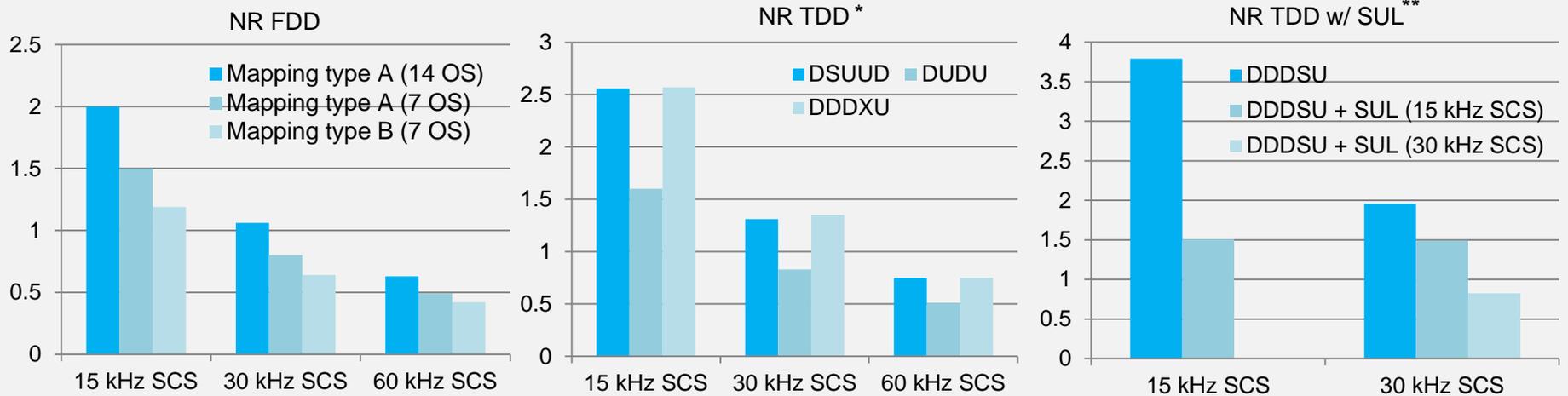
-



User plane latency

- Various configurations are evaluated for NR. See TR37.910 for more details.

UP latency for NR uplink



NR fulfills UL user plane latency requirement for eMBB (4ms) and URLLC (1ms).

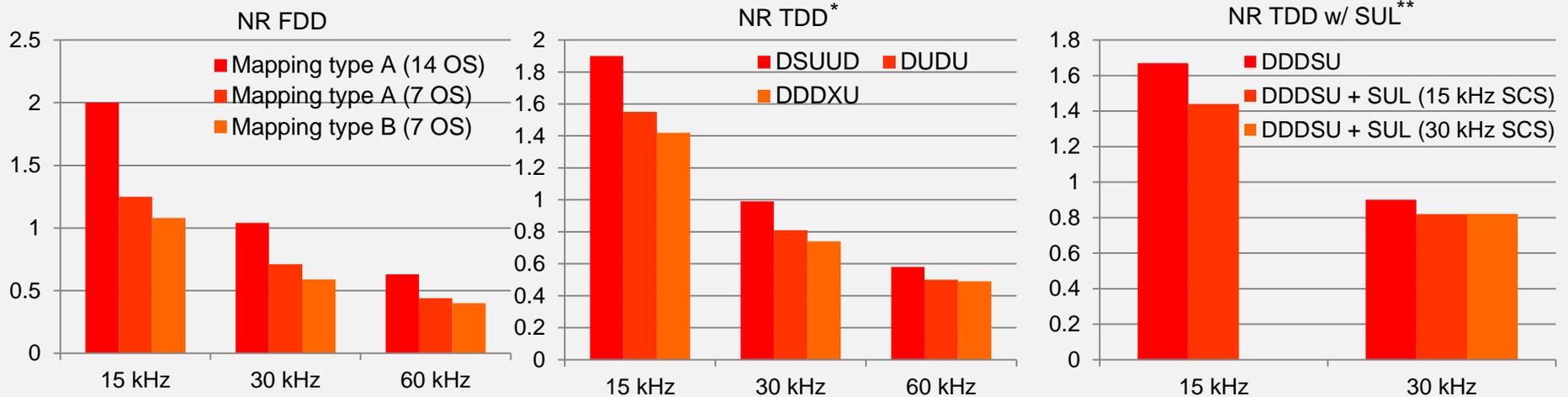
* Mapping type B (7 OS)

** Mapping type A (7 OS)

User plane latency

- Various configurations are evaluated for NR. See TR37.910 for more details.

UP latency for NR downlink



NR fulfills DL user plane latency requirement for eMBB (4ms) and URLLC (1ms).

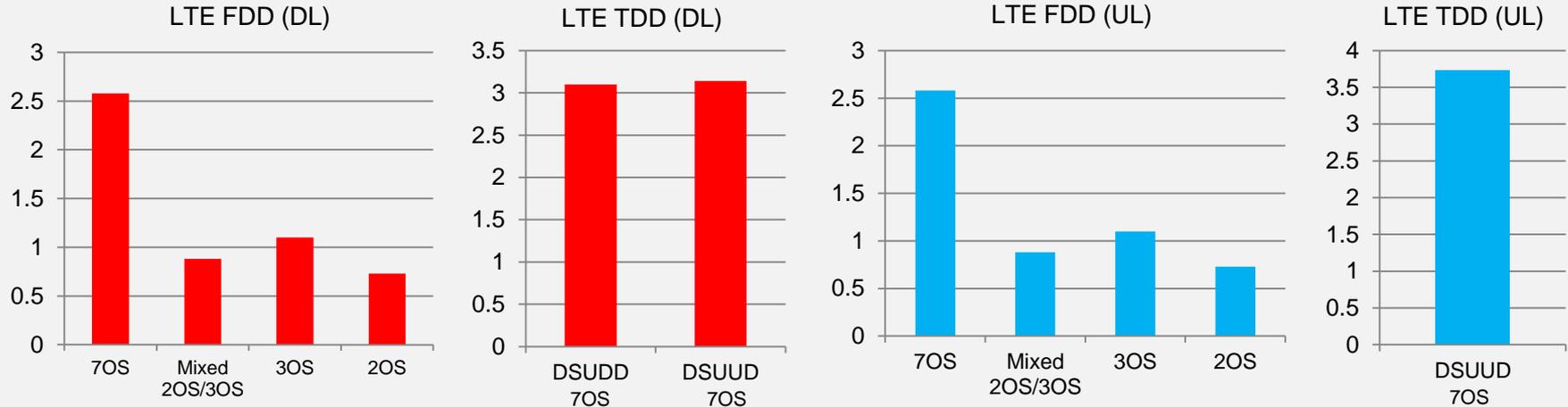
* Mapping type B (7 OS)

** Mapping type A (7 OS)

User plane latency

- Various configurations are evaluated for LTE. See TR37.910 for more details.

UP latency for LTE



LTE fulfills DL and UL user plane latency requirement for eMBB (4ms) and URLLC (1ms).

Control plane latency

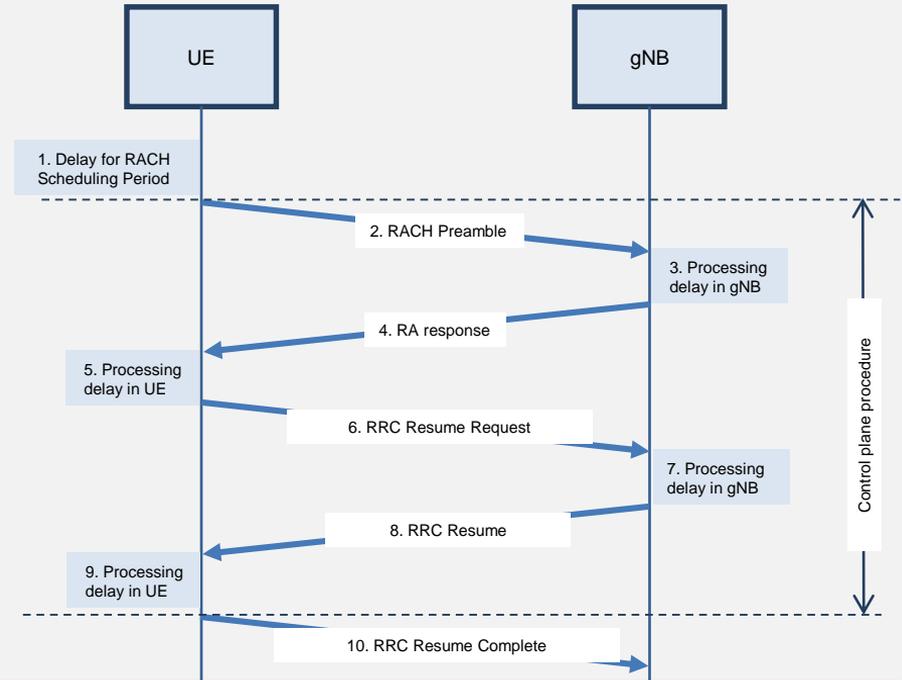
- Contributing technical components for NR include the use of RRC_INACTIVE state, as well as other components similar to UP latency.
- For LTE, the control plane latency is improved compared to Rel-10 by the use of RRC connection resume procedure, as well as by recognizing that some processing delay can be further reduced.

NR

- Both FDD and TDD can reach as low as around 11ms

LTE

- Both FDD and TDD can reach the target: 20ms



NR and LTE fulfill control plane latency requirement for eMBB and URLLC (20ms).

Mobility interruption time

NR

NR fulfills 0ms mobility interruption time in the following scenarios:

- Beam mobility
 - ✓ When moving within the same cell, the transmit-receive beam pair of the UE may need to be changed.
 - ✓ gNB can configure different beams for this UE at different slots. It ensures appropriate transmit/receive beam allocation to the UE for continuous data transmission
- CA mobility
 - When moving within the same PCell with CA enabled, the set of configured SCells of the UE may change.
 - During these procedures, the UE can always exchange user plane packets with the gNB during transitions, because the data transmission between the UE and the PCell is kept.

LTE

LTE fulfills 0ms mobility interruption time in the following scenarios:

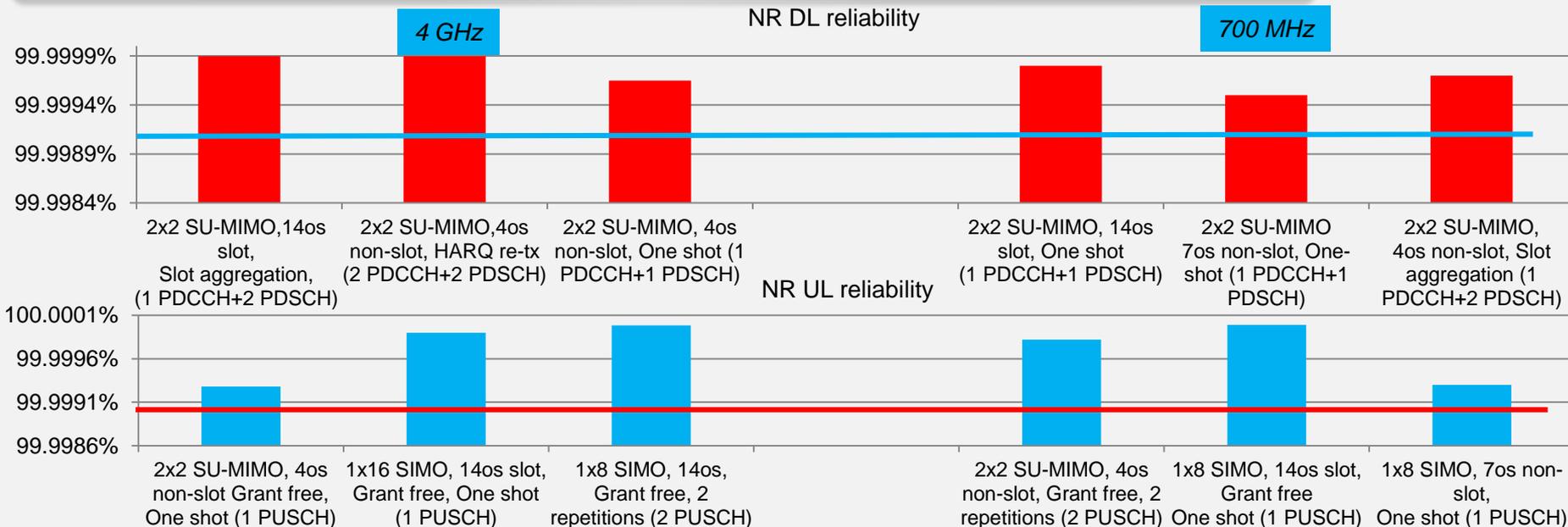
- PCell mobility
 - ✓ See details in Section 5.10 in TR37.910
- DC mobility
 - ✓ See details in Section 5.10 in TR37.910.

NR and LTE fulfill mobility interruption time requirement for eMBB and URLLC (0ms).

Reliability

- Contributing technical components:

- NR frame structure with multiple SCSs is beneficial to reduce the delay.
- Slot aggregation and lower MCS is beneficial to ensure the reliability.



NR fulfills reliability requirement.

Connection density

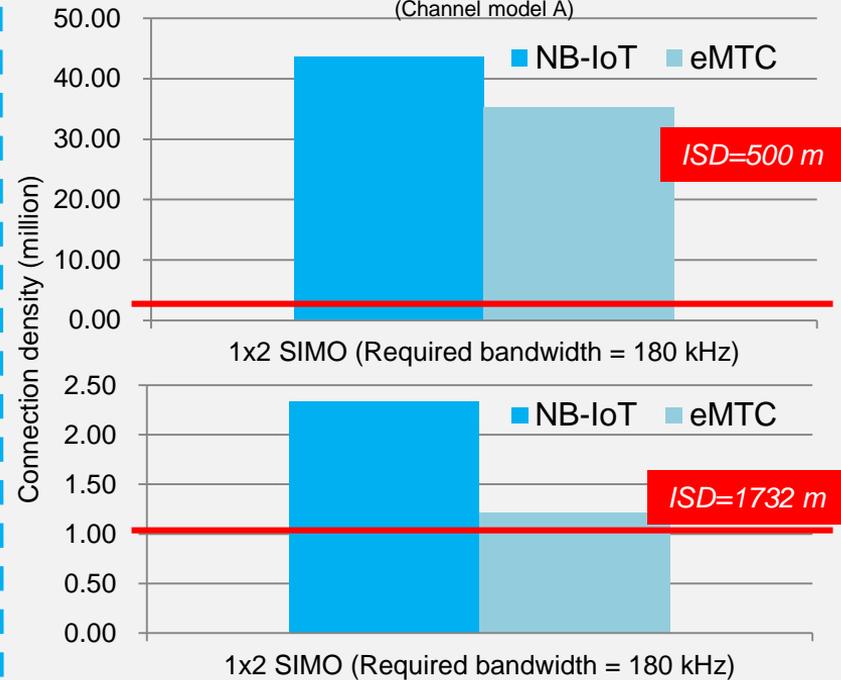
- Connection density for NR, NB-IoT and eMTC are evaluated. See TR37.910 for more details.

Full buffer system level simulation followed by link level simulation; packet arrival rate: 1 packet / 2 hour / device;

NR connection density (1x2 SIMO, 15kHz SCS)
(Channel model B)

ISD (meter)	Required bandwidth (kHz)	Connection density (device/km ²)	Target (device/km ²)
500	180	36,000,000	1,000,000
1732	180	1,503,000	

LTE connection density
(Channel model A)



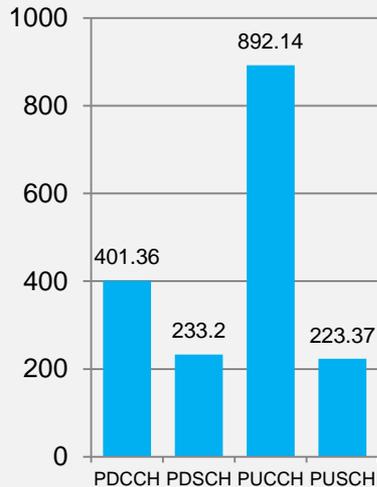
NR fulfills connection density requirement

NB-IoT and eMTC fulfills connection density requirement

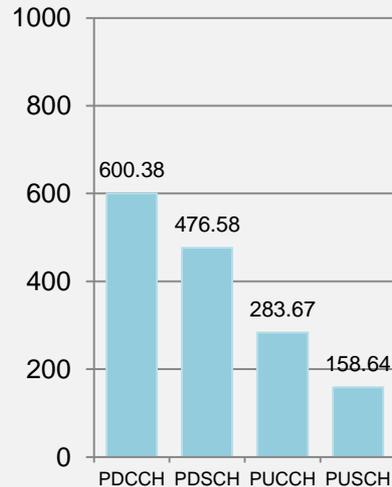
Link budget

- Link budget are provided for NR. See link budget templates for details

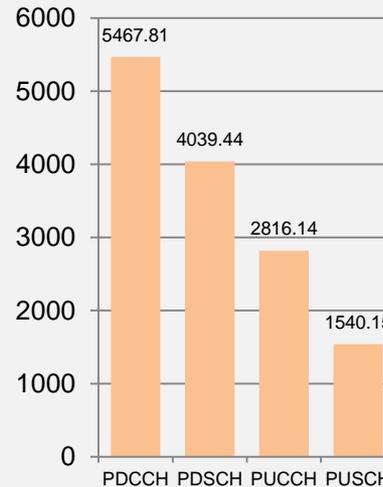
Indoor Hotspot (4GHz, TDD)



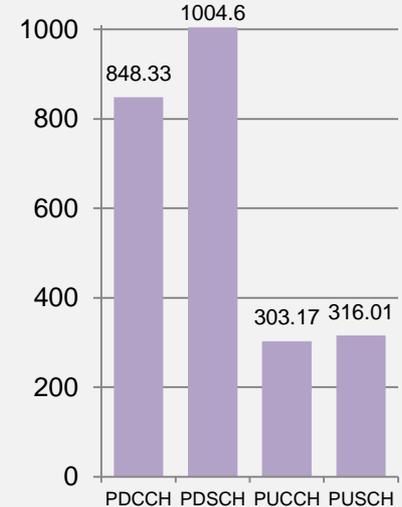
Dense Urban (4GHz, TDD)



Rural (700MHz, FDD)



Urban Macro-URLLC (700MHz, FDD)

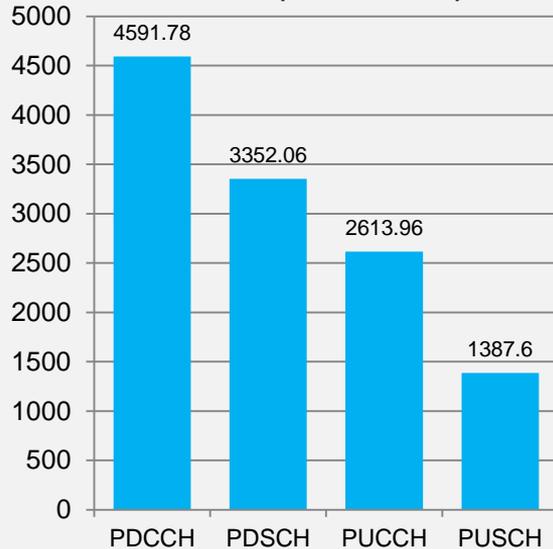


NR link budget for some configurations

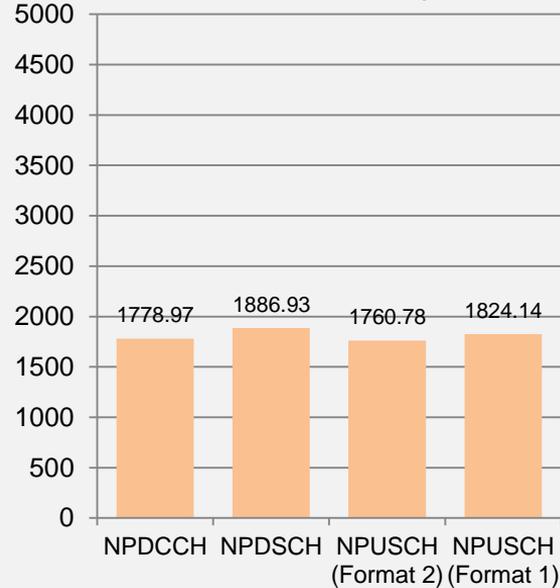
Link budget

- Link budget are provided for LTE. See link budget templates for details

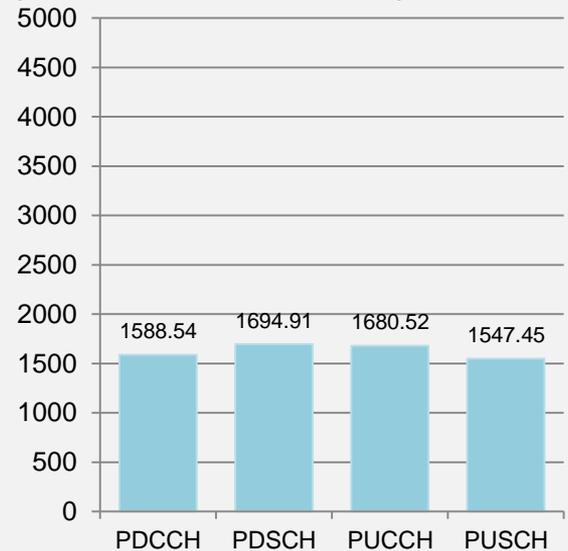
Rural (700MHz, FDD)



Urban Macro-NB-IoT (700MHz, FDD)



Urban Macro-eMTC (700MHz, FDD)



LTE link budget for some configurations

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Conclusion

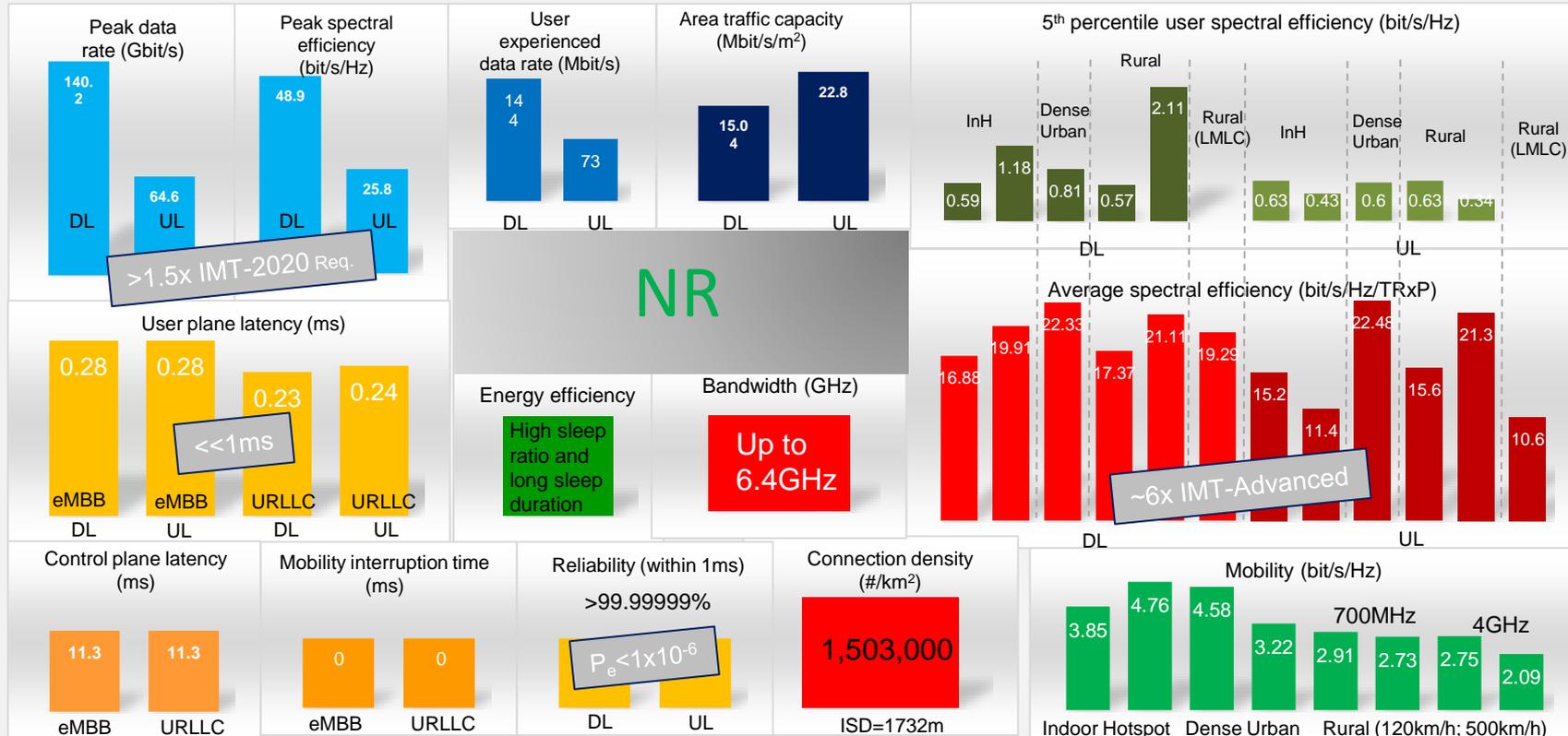
3GPP Compliance to Service and Spectrum Requirement

	Service capability requirements	SRIT (NR+LTE)	NR RIT
5.2.4.1.1	<p>Support for wide range of services</p> <p>Is the proposal able to support a range of services across different usage scenarios (eMBB, URLLC, and mMTC)?: YES/NO</p> <p>Specify which usage scenarios (eMBB, URLLC, and mMTC) the candidate RIT or candidate SRIT can support.</p>	<p>YES</p> <p><i>The SRIT can support eMBB, URLLC and mMTC usage scenarios.</i></p>	<p>YES</p> <p><i>The NR RIT can support eMBB, URLLC and mMTC usage scenarios.</i></p>
	Spectrum capability requirements	SRIT (NR+LTE)	NR RIT
5.2.4.2.1	<p>Frequency bands identified for IMT</p> <p>Is the proposal able to utilize at least one frequency band identified for IMT in the ITU Radio Regulations?: YES /NO</p> <p>Specify in which band(s) the candidate RIT or candidate SRIT can be deployed.</p>	<p>YES</p> <p><i>LTE RIT supports the IMT band from 450 MHz to 5925 MHz.</i></p> <p><i>NR RIT supports the IMT band from 663 MHz to 5000 MHz.</i></p> <p><i>See Section 5.2.3.2.8.3 in characteristics template for details.</i></p>	<p>YES</p> <p><i>NR RIT supports the IMT band from 663 MHz to 5000 MHz, including 3.3-3.8; 3.3-4.2 GHz. See Section 5.2.3.2.8.3 in characteristics template for NR RIT for details.</i></p>
5.2.4.2.2	<p>Higher Frequency range/band(s)</p> <p>Is the proposal able to utilize the higher frequency range/band(s) above 24.25 GHz?: YES</p> <p>Specify in which band(s) the candidate RIT or candidate SRIT can be deployed. (NOTE 1)</p>	<p>YES</p> <p><i>NR RIT supports 24.25-27.5; 27.5-28.35; 26.5-29.5; 37-40 GHz.</i></p>	<p>YES</p> <p><i>NR RIT supports 24.25-27.5; 27.5-28.35; 26.5-29.5; 37-40 GHz.</i></p>

NOTE 1 – In the case of the candidate SRIT, at least one of the component RITs need to fulfil this requirement.

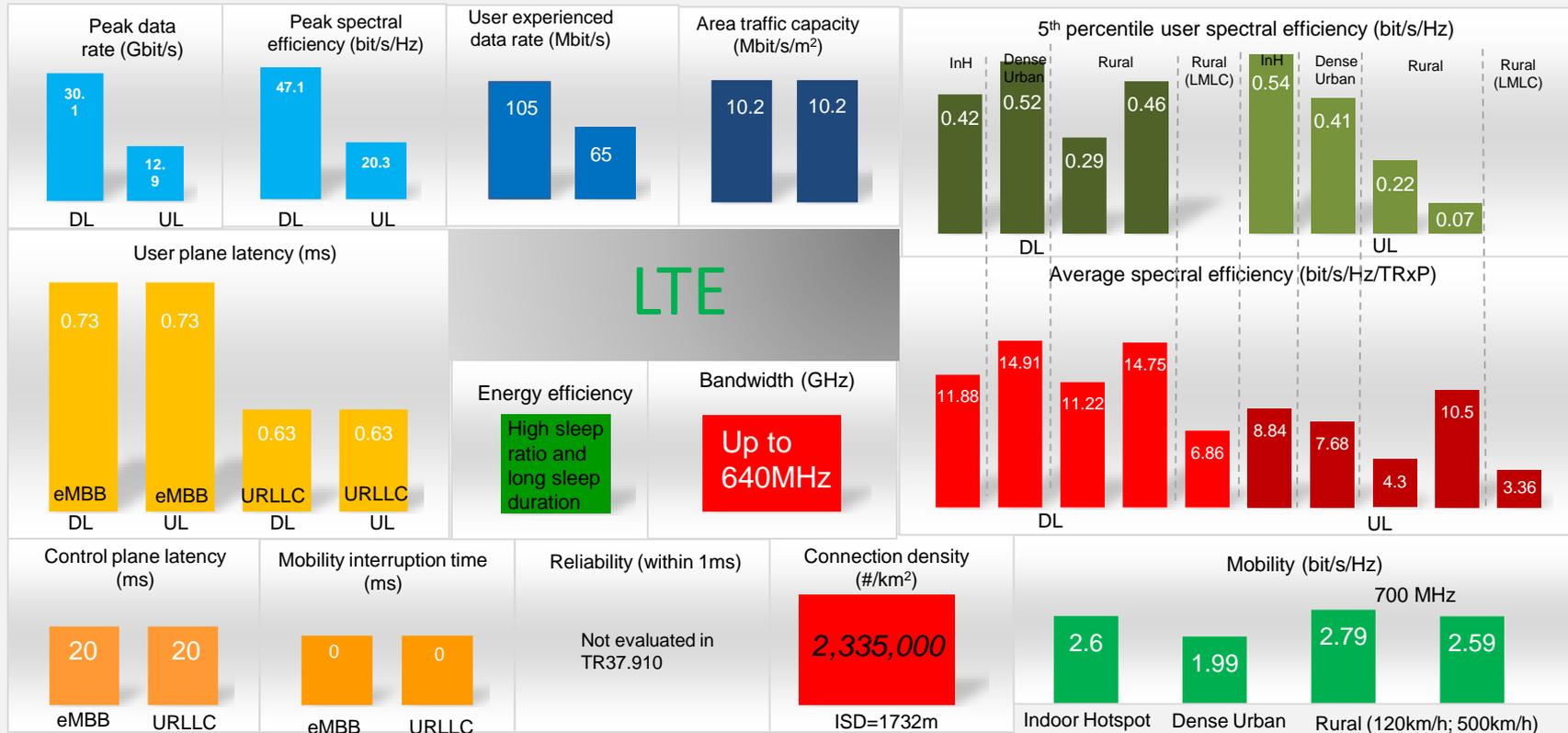
3GPP Compliance to Technical Performance Requirement

- NR fulfills all the technical requirements.



3GPP Compliance to Technical Performance Requirement

- LTE fulfills the technical performance requirements for required number of test environments.



Conclusion

Usage scenario	Sub-items	Evaluation method	Test environment				
			eMBB			mMTC	URLLC
			Indoor hotspot	Dense urban	Rural	Urban macro	Urban macro
eMBB	Peak data rate	Analysis	✓	✓	✓		
	Peak spectral efficiency	Analysis	✓	✓	✓		
	User experienced data rate	Analysis, or SLS (for multi-layer)		✓			
	5 th percentile user spectral efficiency	SLS	✓	✓	✓		
	Average spectral efficiency	SLS	✓	✓	✓		
	Area traffic capacity	Analysis	✓				
	Energy efficiency	Inspection	✓	✓	✓		
	Mobility	SLS + LLS	✓	✓	✓		
eMBB, URLLC	User plane latency	Analysis	✓	✓	✓		✓
	Control plane latency	Analysis	✓	✓	✓		✓
	Mobility interruption time	Analysis	✓	✓	✓		✓
URLLC	Reliability	SLS + LLS					✓
mMTC	Connection density	SLS + LLS, or Full SLS				✓	
General	Bandwidth and Scalability	Inspection	✓	✓	✓	✓	✓

Both 5G SRIT and NR RIT are compliant with all IMT-2020 requirements

Acknowledgement



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Thank you!