## Characteristics template for SRIT of “5G” (Release 15 and beyond)

The description templates provided by 3GPP are for the description of the characteristics of 5G[[1]](#footnote-1) 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 the current 3GPP Rel-15 work.

It is noted that new features in addition to the ones provided in this characteristics template might be included in future update for the SRIT and its component RITs.

For this initial characteristics template, 3GPP has chosen to address the characteristics that are viewed to be very crucial 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 SRIT. In future submission, further information will be included.

| 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?*This proposal addresses all the five test environments across the three usage scenarios (eMBB, mMTC, and URLLC) as described in Report ITU-R M.2412-0.* |
| **5.2.3.2.2** | **Radio interface functional aspects**  |
| 5.2.3.2.2.1 | *Multiple access schemes*Which access scheme(s) does the proposal use? Describe in detail the multiple access schemes employed with their main parameters.***For NR component RIT:**** ***Downlink and Uplink:***

*The multiple access is a combination of** ***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).*
	+ *CP-OFDM is applied for both downlink and uplink. DFT-spread OFDM can also be configured for uplink.*
	+ *Spectral confinement technique(s) (e.g. filtering, windowing, etc.) for a waveform at the transmitter is transparent to the receiver. When such confinement techniques are used, the spectral utilization ratio can be enhanced.*
* ***TDMA****: Transmission to/from different UEs with separation in time. Granularity: One slot consisting of 14 OFDM symbols, or 2, 4, 7 OFDM symbols within one slot. The physical length of one slot ranges from 0.125ms to 1ms depending on the sub-carrier spacing (for more details on the frame structure, see Item 5.2.3.2.7 and the references therein).*
* ***CDMA****: Inter-cell interference suppressed by processing gain of channel coding allowing for a frequency reuse of one (for more details on channel-coding, see Item 5.2.3.2.2.3 and the reference therein).*
* ***SDMA****: Possibility to transmit to/from multiple users using the same time/frequency resource (SDMA a.k.a. “multi-user MIMO”) as part of the advanced-antenna capabilities (for more details on the advanced-antenna capabilities, see Item 5.2.3.2.9 and the reference therein)*

*At least an UL transmission scheme without scheduling grant is supported.**The above scheme is at least applied to eMBB and URLLC.**(Note: Synchronous means that timing offset between UEs is within cyclic prefix by e.g. timing alignment.)****For LTE*** ***component RIT:**** ***Downlink and Uplink:***

*The multiple access is a combination of** ***OFDMA****: Synchronous/scheduling-based is supported for both DL and UL; the transmission to/from different UEs uses mutually orthogonal frequency assignments. In addition, non-orthogonal multiple access is supported for DL (known as MUST, see [36.211] sub-clause 7.1.2 for more details). Granularity in frequency assignment: One resource block consisting of 12 subcarriers. Sub-carrier spacings of 15kHz is supported for uni-cast data and subcarrier spacings of 15kHz, 7.5kHz and 1.25kHz are supported for multi-cast data (see Item 5.2.3.2.7 and reference therein).*
	+ *CP-OFDM is applied for downlink. DFT-spread OFDM is applied for uplink.*
* ***TDMA****: Transmission to/from different UEs with separation in time. Granularity: One subframe of length 1 ms, or slot of 7 OFDM symbols (0.5ms), or sub-slot of length 2~3 OFDM symbols (0.143ms~0.214ms) (for more details on the frame structure, see Item 5.2.3.2.7 and the references therein).*
* ***CDMA****: Inter-cell interference suppressed by processing gain of channel coding allowing for a frequency reuse of one (for more details on channel-coding, see Item 5.2.3.2.2.3 and the reference therein).*
* ***SDMA****: Possibility to transmit to/from multiple users using the same time/frequency resource (SDMA a.k.a. “multi-user MIMO”) as part of the advanced-antenna capabilities (for more details on the advanced-antenna capabilities, see Item 5.2.3.2.9 and the reference therein)*

*For NB-IoT, the multiple access is a combination of OFDMA, TDMA and CDMA, where OFDMA and TDMA are as follows** ***OFDMA:***
	+ *UL: DFT-spread OFDM. Granularity in frequency domain: A single sub-carrier with either 3.75 kHz or 15 kHz sub-carrier spacing, or 3, 6, or 12 sub-carriers with a sub-carrier spacing of 15 kHz. A resource block consists of 12 sub-carriers with 15 kHz sub-carrier spacing, or 48 sub-carriers with 3.75 kHz sub-carrier spacing → 180 kHz.*
	+ *DL: Granularity in frequency domain: one resource block consisting of 12 subcarriers with 15 kHz sub-carrier spacing→ 180 kHz*
* ***TDMA:*** *Transmission to/from different UEs with separation in time*
	+ *UL: Granularity: One resource unit of 1 ms, 2 ms, 4 ms, 8 ms, with 15 kHz sub-carrier spacing, depending on allocated number of sub-carrier(s); or 32 ms with 3.75 kHz sub-carrier spacing (for more details on the frame structure, see Item 5.2.3.2.7 and the references therein)*
	+ *DL: Granularity: One resource unit (subframe) of length 1 ms.*
	+ *Repetition of a transmission is supported.*
 |
| 5.2.3.2.2.2 | *Modulation scheme* |
| 5.2.3.2.2.2.1 | What is the baseband modulation scheme? If both data modulation and spreading modulation are required, describe in detail.Describe the modulation scheme employed for data and control information.What is the symbol rate after modulation?***For NR component RIT:**** ***Downlink:***
* *For both data and higher-layer control information: QPSK, 16QAM, 64QAM and 256QAM (see [38.211] sub-clause 7.3.1.2).*
* *L1/L2 control: QPSK (see [38.211] sub-clause 7.3.2.4).*
* *Symbol rate: 1344ksymbols/s per 1440kHz resource block (equivalently 168ksymbols/s per 180kHz resource block)*
* ***Uplink:***
* *For both data and higher-layer control information: π/2-BPSK (when precoding is enabled), QPSK, 16QAM, 64QAM and 256QAM (see [38.211] sub-clause 6.3.1.2).*
* *L1/L2 control: BPSK, π/2-BPSK, QPSK (see [38.211] sub-clause 6.3.2).*
* *Symbol rate: 1344ksymbols/s per 1440kHz resource block (equivalently 168ksymbols/s per 180kHz resource block)*

*The above is at least applied to eMBB.****For LTE component RIT:**** ***Downlink:***
* *For both data and higher-layer control information: QPSK, 16QAM, 64QAM and 256QAM (see [36.211] sub-clause 6.3.2). 1024QAM is being specified.*
* *L1/L2 control: QPSK (see [36.211] sub-clauses 6.7.2, 6.8.3, and 6.8A.3)*
* *Symbol rate: 168ksymbols/s per 180kHz resource block*
* ***Uplink:***
* *For both data and higher-layer control information: QPSK, 16QAM, 64QAM and 256QAM are supported (see [36.211] sub-clause 5.3.2).*
* *L1/L2 control: BPSK, QPSK (see [36.211] sub-clause 5.4)*
* *Symbol rate: 168ksymbols/s per 180kHz resource block*

*For NB-IoT, the modulation scheme is as follows.** *Data and higher-layer control: π/2-BPSK (uplink only), π/4-QPSK (uplink only), QPSK*
* *L1/L2 control: π/2-BPSK (uplink), QPSK (downlink)*

*Symbol rate: 168 ksymbols/s per 180 kHz resource block. For UL, less than one resource block may be allocated.* |
| 5.2.3.2.2.2.2 | *PAPR*What is the RF peak to average power ratio after baseband filtering (dB)? Describe the PAPR (peak-to-average power ratio) reduction algorithms if they are used in the proposed RIT/SRIT.*The PAPR depends on the waveform and the number of component carriers. The single component carrier transmission is assumed herein when providing the PAPR. For DFT-spread OFDM, PAPR would depend on modulation scheme as well.**For uplink using DFT-spread OFDM, the cubic metric (CM) can also be used as one of the methods of predicting the power de-rating from signal modulation characteristics, if needed.* ***For NR component RIT:**** ***Downlink:***

*The PAPR is 8.4dB (99.9%)** ***Uplink:***
* *For CP-OFDM:*

*The PAPR is 8.4dB (99.9%)** *For DFT-spread OFDM:*

*The PAPR is provided in the table below.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Modulation | *π*/2 BPSK | QPSK | 16QAM | 64QAM | 256QAM |
| PAPR (99.9%) | 4.5 dB | 5.8 dB | 6.5 dB | 6.6 dB | 6.7 dB |
| CM(99.9%) | 0.3 dB | 1.2 dB | 2.1 dB | 2.3 dB | 2.4 dB |

*Note: The above values are derived without spectrum shaping. When spectrum shaping is considered for π/2 BPSK, lower PAPR and CM values can be derived, e.g., 1.75dB PAPR for π/2 BPSK, based on the trade-off between PAPR and demodulation performance.**Spectrum shaping can be used for a user with π/2 BPSK DFT-S-OFDM for above 24 GHz.****For LTE component RIT:**** ***Downlink:***

*The PAPR is 8.4dB (99.9%).** ***Uplink:***
* *For DFT-spread OFDM:*

*The PAPR is provided in the table below.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Modulation | QPSK | 16QAM | 64QAM | 256QAM |
| PAPR (99.9%) | 5.8 dB | 6.5 dB | 6.6 dB | 6.7 dB |
| CM(99.9%) | 1.2 dB | 2.1 dB | 2.3 dB | 2.4 dB |

*For NB-IoT,* * ***Downlink:***

*The PAPR is 8.0dB (99.9%) on 180kHz resource.** ***Uplink:***

*The PAPR is 0.23 – 5.6 dB (99.9 %) depending on sub-carriers allocated for available NB-IoT UL modulation.****PAPR-reduction algorithm for NR and LTE:****Any PAPR-reduction algorithm is transmitter-implementation specific for uplink and downlink.* |
| 5.2.3.2.2.3  | *Error control coding scheme and interleaving* |
| 5.2.3.2.2.3.1 | Provide details of error control coding scheme for both downlink and uplink.For example, – FEC or other schemes?The proponents can provide additional information on the decoding schemes.***For NR component RIT:**** ***Downlink and Uplink:***
* *For data: Rate 1/3 or 1/5 Low density parity check (LDPC) coding, combined with rate matching based on puncturing/repetition to achieve a desired overall code rate (For more details, see [38.212] sub-clauses 5.3.2). LDPC channel coder facilitates low-latency and high-throughput decoder implementations.*
* *For L1/L2 control: For DCI (Downlink Control Information)/UCI (Uplink Control Information) size larger than 11 bits, Polar coding, combined with rate matching based on puncturing/repetition to achieve a desired overall code rate (For more details, see [38.212] sub-clauses 5.3.1). Otherwise, repetition for 1-bit; simplex coding for 2-bit; reedmuller coding for 3~11-bit DCI/UCI size.*

*The above scheme is at least applied to eMBB.****For LTE component RIT:**** ***Downlink and Uplink:***
* *For data:* *Rate 1/3 Turbo coding, combined with rate matching based on puncturing/repetition to achieve a desired overall code rate (For more details, see [36.212] sub-clauses 5.1.3.2)*
* *For L1/L2 control: Rate-1/3 tail-biting convolutional coding. Special block codes for some L1/L2 control signaling (For more details, see [36.212] sub-clauses 5.1.3.1)*

*For NB-IoT, the coding scheme is as follows:** *For data: Rate 1/3 Turbo coding in UL, and rate-1/3 tail-biting convolutional coding in DL, each combined with rate matching based on puncturing/repetition to achieve a desired overall code rate; one transport block can be mapped to one or multiple resource units (for more details, see [36.212] sub-clause 6.2)*
* *For L1/L2 control: The same as above.*

***Decoding schemes for NR and LTE:****Decoding mechanism is receiver-implementation specific. Example of information on the decoding mechanism will be provided together with self evaluation.* |
| 5.2.3.2.2.3.2 | Describe the bit interleaving scheme for both uplink and downlink.***For NR component RIT:**** ***Downlink:***
* *For data:* *bit interleaver is performed for LDPC coding after rate-matching (For more details, see [38.212] sub-clauses 5.4.2.2)*
* *For L1/L2 control: Bit interleaving is performed as part of the encoding process for Polar coding (For more details, see [38.212] sub-clauses 5.4.1.1)*
* ***Uplink:***
* *For data: bit interleaver is performed for LDPC coding after rate-matching (For more details, see [38.212] sub-clauses 5.4.2.2)*
* *For L1/L2 control: Bit interleaving is performed for Polar coding after rate-matching (For more details, see [38.212] sub-clauses 5.4.1.3)*

*The above scheme is at least applied to eMBB.****For LTE component RIT:**** ***Downlink and Uplink:***

*Bit interleaving is performed as part of the encoding/rate-matching process, see [36.212] sub-clauses 5.1.3 and 5.1.4 for more details.* *Additional interleaving is performed in uplink, see [36.212] sub-clause 5.2.2.8 for more details.* |
| **5.2.3.2.3** | **Describe channel tracking capabilities (e.g. channel tracking algorithm, pilot symbol configuration, etc.) to accommodate rapidly changing delay spread profile.*****For NR component RIT:****To support channel tracking, different types of reference signals can be transmitted on downlink and uplink respectively.** ***Downlink:***
* ***Primary and Secondary Synchronization signals (PSS and SSS)*** *are transmitted periodically to the cell. The periodicity of these signals is network configurable. UEs can detect and maintain the cell timing based on these signals. If the gNB implements hybrid beamforming, then the PSS and SSS are transmitted separately to each analogue beam.* *Network can configure multiple PSS and SSS in frequency domain.*
* ***UE-specific Demodulation RS (DM-RS)*** *for PDCCH can be used for downlink channel estimation for coherent demodulation of PDCCH (Physical Downlink Control Channel). DM-RS for PDCCH is transmitted together with the PDCCH.*
* ***UE-specific Demodulation RS (DM-RS)*** *for PDSCH can be used for downlink channel estimation for coherent demodulation of PDSCH (Physical Downlink Shared Channel). DM-RS for PDSCH is transmitted together with the PDSCH.*
* ***UE-specific Phase Tracking RS (PT-RS)*** *can be used in addition to the DM-RS for PDSCH for correcting common phase error between PDSCH symbols not containing DM-RS. It may also be used for Doppler and time varying channel tracking. PT-RS for PDSCH is transmitted together with the PDSCH upon need.*
* ***UE-specific Channel State Information RS (CSI-RS)*** *can be used for estimation of channel-state information (CSI) to further prepare feedback reporting to gNB to assist in MCS selection, beamforming, MIMO rank selection and resource allocation. CSI-RS transmissions are transmitted periodically, aperiodically, and semi-persistently on a configurable rate by the gNB. CSI-RS also can be used for interference measurement and fine frequency/time tracking purposes.*
* ***Uplink:***
* ***UE-specific Demodulation RS (DM-RS)*** *for PUCCH can be used for uplink channel estimation for coherent demodulation of PUCCH (Physical Uplink Control Channel). DM-RS for PUCCH is transmitted together with the PUCCH.*
* ***UE-specific Demodulation RS (DM-RS)*** *for PUSCH can be used for uplink channel estimation for coherent demodulation of PUSCH (Physical Uplink Shared Channel). DM-RS for PUSCH is transmitted together with the PUSCH.*
* ***UE-specific Phase Tracking RS (PT-RS)*** *can be used in addition to the DM-RS for PUSCH for correcting common phase error between PUSCH symbols not containing DM-RS. It may also be used for Doppler and time varying channel tracking. DM-RS for PUSCH is transmitted together with the PUSCH upon need.*
* ***UE-specific Sounding RS (SRS)*** *can be used for estimation of uplink channel-state information to assist uplink scheduling, uplink power control, as well as assist the downlink transmission (e.g. the downlink beamforming in the scenario with UL/DL reciprocity). SRS transmissions are transmitted periodically by the UE on an gNB configurable rate.*

*Details of channel-tracking/estimation algorithms are receiver-implementation specific, and not part of the specification.****For LTE*** ***component RIT:**** ***Downlink:***
* ***Cell-specific RS*** *(CRS) are transmitted in every non-MBSFN subframe and over the entire frequency band unless Discovery Reference Signals are transmitted. Up to four different CRS can be transmitted within a cell, with each CRS corresponding to one of up to four cell-specific antenna ports, referred to antenna port 0 to 3 respectively.  The CRS can be used for downlink channel estimation for coherent demodulation of physical channels transmitted from antenna ports 0 to 3. The CRS can also be used to derive channel-state information (CSI) for the corresponding antenna ports. The CSI can e.g. be used to assist scheduling (including link adaptation, precoder-matrix/vector selection, etc.). For the detailed structure of CRS, see [36.211] sub-clause 6.10.1.*
* ***UE-specific RS*** *can be used for downlink channel estimation for coherent demodulation of PDSCH (Physical Downlink Shared Channel). Up to eight different UE-specific reference signals corresponding to up to eight layers can be transmitted from a UE point-of-view. In a given subframe, the UE-specific reference signals are only transmitted within the resource blocks that are used for PDSCH transmission to the specific UE within this subframe. For the detailed structure of UE-specific RS for the case of transmission from a single antenna port (a.k.a. antenna port 5), see [36.211] sub-clause 6.10.3. The structure for the case of transmission from multiple antenna ports is an extension of the structure for the case of a single antenna port.*
* ***CSI-RS*** *can be used for estimation of channel-state information (CSI) to further prepare feedback reporting to eNB (CQI for link adaptation, precoder-matrix/vector selection, etc.) to assist beamforming and scheduling for up to eight layers of transmission. CSI-RS are transmitted in every Nth subframe, where N is configurable.*
* ***Discovery Reference Signals*** *(DRS) are a combination of Primary and Secondary Synchronization Signals (PSS and SSS), CRS, and possibly CSI-RS. Discovery Reference Signals are transmitted in every Nth subframe, where N is configurable. Discovery Reference Signals can be used for link-adaptation, precoder selection, and radio resource management related measurements in cases where CRS are not transmitted in every subframe to e.g. save power or reduce interference.*
* ***Narrowband Reference signals*** *(NRS) are used in NB-IoT. NRS are transmitted in a certain minimum set of subframes which depends on the in-band, guard-band, or standalone nature of the deployment, and additionally in a configured set of subframes. NRS associated with paging, random access response, and multicast transmissions on non-anchor NB-IoT carriers do not have to be transmitted on subframes far away from the associated transmissions, even if they are in the configured set of subframes. Up to two different NRS can be transmitted within a cell, with each NRS corresponding to one of up to two cell-specific antenna ports, referred to as antenna port 2000 to 2001 respectively. The NRS can be used for downlink channel estimation for coherent demodulation of physical channels transmitted from antenna ports 2000 to 2001. For the detailed structure of NRS, see [36.211] sub-clause 10.2.6.*
* ***Uplink:***
* ***Demodulation RS*** *(DMRS) can be used for channel estimation for coherent demodulation of the Physical Uplink Shared Channel (PUSCH), and the Physical Uplink Control Channel (PUCCH). Uplink DMRS for demodulation of PUSCH are transmitted once every slot (twice every subframe) in the subframes in which PUSCH is being transmitted. Up to four uplink DMRS can be transmitted from a UE. The instantaneous bandwidth of the uplink DMRS equals the instantaneous bandwidth of the corresponding PUSCH transmission.*
	+ *For the detailed structure of uplink DMRS for PUSCH transmission for the case of single antenna transmission, see [36.211] sub-clause 5.5.2.1. The structure for the case of transmission from multiple antenna ports is an extension of the structure for the case of a single antenna port.*
* *For NB-IoT, uplink DMRS for demodulation of NPUSCH are transmitted once every slot (twice every subframe) in the subframes in which NPUSCH is being transmitted. The instantaneous bandwidth of the uplink DMRS equals the instantaneous bandwidth of the corresponding NPUSCH transmission. One DMRS for NPUSCH transmission can be transmitted from a UE. For the detailed structure of uplink DMRS for NPUSCH transmission, see [36.211] sub-clause 10.1.4.*
* ***Sounding RS*** *(SRS) can be used for estimation of uplink channel-state information to assist uplink scheduling, uplink power control, and also assist downlink transmissions (e.g. downlink beamforming in scenarios with UL/DL reciprocity). Uplink SRS are transmitted either periodically every Nth subframe, where N is configurable, or aperiodically when triggered by the network. For the detailed structure of uplink SRS see [36.211] sub-clause 5.5.3.*

*Details of channel-tracking/estimation algorithms are receiver-implementation specific, e.g. MMSE-based channel estimation with appropriate interpolation in time and frequency domain could be used.* |
| **5.2.3.2.4** | **Physical channel structure and multiplexing**  |
| 5.2.3.2.4.1 | What is the physical channel bit rate (M or Gbit/s) for supported bandwidths?i.e., the product of the modulation symbol rate (in symbols per second), bits per modulation symbol, and the number of streams supported by the antenna system.***For NR component RIT:****The physical channel bit rate depends on the modulation scheme, number of spatial-multiplexing layer, number of resource blocks in the channel bandwidth and the subcarrier spacing used. The physical channel bit rate per layer can be expressed as* *Rlayer = Nmod* x *NRB* *x* 2*µ* x 168 *kbps* *where* * *Nmod is the number of bits per modulation symbol for the applied modulation scheme (QPSK: 2, 16QAM: 4, 64QAM: 6, 256QAM: 8)*
* *NRB is the number of resource blocks in the aggregated frequency domain which depends on the channel bandwidth.*
* *µ depends on the subcarrier spacing,* $∆f$*, given by* $∆f=2^{μ}∙15 \left[kHz\right], μ=0,1,…3$

*For example, a 400 MHz carrier with 264 resource blocks using 120 kHz subcarrier spacing,* $μ=3$*, and 256QAM modulation results in a physical channel bit rate of 2.8 Gbit/s per layer.****For LTE component RIT:****The physical channel bit rate depends on the modulation scheme, number of spatial-multiplexing layers and number of resource blocks in the channel bandwidth. The physical channel bit rate per layer can be expressed as* *Rlayer = Nmod* x *NRB* x *168 kbps* *where* * *Nmod is the number of bits per modulation symbol for the applied modulation scheme (QPSK: 2, 16QAM: 4, 64QAM: 6, 256QAM: 8, 1024QAM: 10)*
* *NRB is the number of resource blocks in the aggregated frequency domain which depends on the channel bandwidth (e.g. NRB =25 for 5 MHz, NRB =50 for 10 MHz, and NRB =100 for 20 MHz. For channel bandwidth larger than 20 MHz (carrier aggregation), the channel bit rate will scale accordingly.*

*NB-IoT only supports transmission of a single layer and the physical channel bit rate is as above, but with Nmod limited to 1(BPSK) or 2 (QPSK) and NRB= 1. For MBMS, 1.25 kHz and 7.5 kHz subcarrier spacing are also supported, scaling the physical channel bit rate accordingly.* |
| 5.2.3.2.4.2 | *Layer 1 and Layer 2 overhead estimation.*Describe how the RIT/SRIT accounts for all layer 1 (PHY) and layer 2 (MAC) overhead and provide an accurate estimate that includes static and dynamic overheads.***For NR component RIT:**** ***Downlink***

*The downlink L1/L2 overhead includes:*1. *Different types of reference signals*
	1. *Demodulation reference signals for PDSCH (DMRS-PDSCH)*
	2. *Phase-tracking reference signals for PDSCH (PTRS-PDSCH)*
	3. *Demodulation reference signals for PDCCH*
	4. *Reference signals specifically targeting estimation of channel-state information (CSI-RS)*
	5. *Tracking reference signals (TRS)*
2. *L1/L2 control signalling transmitted on the up to three first OFDM symbols of each slot*
3. *Synchronization signals and physical broadcast control channel including demodulation reference signals included in the SS/PBCH block*
4. *PDU headers in L2 sub-layers (MAC/RLC/PDCP)*

*The overhead due to different type of reference signals is given in the table below. Note that demodulation reference signals for PDCCH is included in the PDCCH overhead.*

|  |  |  |
| --- | --- | --- |
| *Reference signal type* | *Explanation*  | *Overhead* |
| *DMRS-PDSCH* | *½, 1, 2, 3 or 4 symbols per slot can be configured* | *4 % to 29 %* |
| *PTRS- PDSCH* | *1 resource elements in frequency domain every second resource block* | *0.5 %*  |
| *CSI-RS* | *1 resource element per resource block per antenna port* | *0.25 % for 8 antenna ports transmitted every 20 ms with 15 kHz subcarrier spacing* |
| *TRS* | *2 slots with 2 symbols in each with comb-4* | *0.36 % if transmitted every 20 ms with 15 kHz subcarrier spacing* |

*The overhead due to the L1/L2 control signalling is depending on the size and periodicity of the configured CORESET in the cell and includes the overhead from the PDCCH demodulation reference signals. If the CORESET is transmitted in every slot, maximum control channel overhead is 21% assuming three symbols and whole carrier bandwidth used for CORESET, while a more typical overhead is 7% when 1/3 of the time and frequency resources in the first three symbols of a slot is allocated to PDCCH.**The overhead due to the SS/PBCH block is given by the number of SS/PBCH blocks transmitted within the SS/PBCH block period, the SS/PBCH block periodicity and the subcarrier spacing. Assuming a 100 resource block wide carrier, the overhead for 20 ms periodicity is in the range of 0.6 % to 2.3 % if the maximum number of SS/PBCH blocks are transmitted.** ***Uplink***

*L1/L2 overhead includes:*1. *Different types of reference signals*
	1. *Demodulation reference signal for PUSCH*
	2. *Demodulation reference signal for PUCCH*
	3. *Phase-tracking reference signals*
	4. *Sounding reference signal (SRS) used for uplink channel-state estimation at the network side*
2. *L1/L2 control signalling transmitted on a configurable amount of resources (see also Item 4.2.3.2.4.5)*
3. *L2 control overhead due to e.g., random access, uplink time-alignment control, power headroom reports and buffer-status reports*
4. *PDU headers in L2 layers (MAC/RLC/PDCP)*

*The overhead due to due to demodulation reference signal for PUSCH is the same as the overhead for demodulation reference signal for PDSCH, i.e. 4 % to 29 % depending on number of symbols configured. Also, the phase-tracking reference signal overhead is the same in UL as in DL.**The overhead due to periodic SRS is depending on the number of symbols configured subcarrier spacing and periodicity. For 20 ms periodicity, the overhead is in the range of 0.4% to 1.4% assuming15 kHz subcarrier spacing.**Amount of uplink resources reserved for random access depends on the configuration.* *The relative overhead due to uplink time-alignment control depends on the configuration and the number of active UEs within a cell.* *The amount of overhead for buffer status reports depends on the configuration.* *The amount of overhead caused by 4 highly depends on the data packet size.****For LTE component RIT:**** ***Downlink***

*The downlink L1/L2 overhead includes:*1. *Different types of reference signals*
2. *Cell-specific RS (CRS) transmitted within each resource block*
3. *UE-specific demodulation RS*
4. *Reference signals specifically targeting estimation of channel-state information (CSI-RS)*
5. *MBSFN reference signal*
6. *Positioning reference signals*
7. *L1/L2 control signalling transmitted on the up to three (four in case of 1.4 MHz bandwidth) first OFDM symbols of each subframe, except for short TTI operation where L1/L2 control signaling is also transmitted in OFDM symbols associated with the short TTI.*
8. *Synchronization signal and physical broadcast control channel*
9. *PDU headers in L2 sub-layers (MAC/RLC/PDCP)*

*The combined overhead due to CRS (1a) and L1/L2 control signaling (2) depends on the number of cell-specific antenna ports and the number of OFDM symbols used for the L1/L2 control signaling. Some examples, for the case of no CSI-RS and no UE-specific RS, see 4.2.3.2.3 above, are shown below:** + *1 antenna port for CRS and 1 symbol for L1/L2 control: 10.7%*
	+ *1 antenna port for CRS and 3 symbols for L1/L2 control: 25%*
	+ *4 antenna ports for CRS and 1 symbol for L1/L2 control: 19%*
	+ *4 antenna ports for CRS and 3 symbols for L1/L2 control: 31%*

*The amount of overhead caused by synchronization signals and broadcast channel depends on operation bandwidth, and is approximately 0.7% and 0.35%, for 10 and 20MHz operation bandwidth, respectively.**The amount of overhead caused by L2 highly depends on the data packet size, and is approximately 2.7%, 0.51% and 0.32% for L1 data rates of 1, 10 and 100 Mbit/s, respectively.* *In a typical case, the relative overhead for CSI-RS (if present) is estimated to 0.12% per antenna port (0.96% for eight antenna ports).**The relative overhead due to UE-specific RS (if present) is estimated to be approximately 7% in case of Rank 1 and Rank 2 transmission, and 14% for Rank 3-8 transmission.* *In the case of operation with short TTI there will be some additional overhead due to control and reference signals.* *For eMTC, there will be some additional overhead due to eMTC specific narrowband control channel and the need to accommodate wideband LTE control signalling.**For NB-IoT, the overhead from Narrowband RS (NRS) is dependent on the number of cell-specific antenna ports N (1 or 2) and equals 8 x N / 168 %.**The overhead from NB-IoT downlink control signaling is dependent on the amount of data to be transmitted. For small infrequent data transmissions, the downlink transmissions are dominated by the L2 signaling during the connection setup. The overhead from L1 signaling is dependent on the configured scheduling cycle.**The overhead due to Narrowband synchronization signal and Narrowband system information broadcast messages is only applicable to the NB-IoT anchor carrier. The actual overhead depends on the broadcasted system information messages and their frequency. The overhead can be estimated to be around 26.25%.** ***Uplink***

*L1/L2 overhead includes:* 1. *Demodulation reference symbols used e.g. for uplink channel estimation for uplink coherent demodulation, transmitted once every 0.5 ms slot.*
2. *Sounding reference signal (SRS) used for uplink channel-state estimation at the network side*
3. *L1/L2 control signalling transmitted on configurable amount of resource blocks (see also Item 5.2.3.2.4.5)*
4. *L2 control overhead due to e.g., random access, uplink time-alignment control, power headroom reports and buffer-status reports*
5. *PDU headers in L2 layers (MAC/RLC/PDCP)*

*The amount of overhead caused by 1 is approximately 14%, corresponding to one DFTS-OFDM symbol in each slot. The relative overhead is estimated to be independent of the rank of the transmission. With short TTI the DMRS overhead may increase.**The amount of SRS overhead depends on the SRS transmission interval, SRS bandwidth and the usage of UpPTS for SRS. With a 10 msec SRS transmission interval and full band SRS, the relative overhead is approximately 0.7%**Amount of uplink resources reserved for random access depends on the configuration.* *A typical case with PRACH format 0 is six resource blocks per radio frame, implying a relative overhead of 0.6%, 1.2%, and 2.4% for a channel bandwidth of 20 MHz, 10 MHz, and 5 MHz respectively.**The relative overhead due to uplink time-alignment control depends on the configuration and the number of active UEs within a cell. The absolute overhead is typically less than 32 bps per UE.**The amount of overhead for buffer status reports depends on the configuration. With continuous data and a 10 - 20 ms reporting interval the absolute overhead is 0.8-3.2 kbps.**The amount of overhead caused by 5 highly depends on the data packet size, and is approximately 2.7%, 0,51% and 0,32% for L1 data rates of 1, 10 and 100 Mbit/s, respectively.**Above overhead calculations are based on normal CP length.* *For NB-IoT UL, data and control is sharing the same resources and the overhead from L1/L2 control signaling depend on the scheduled traffic in the DL. The UL control signaling is dominated by RLC and HARQ positive or negative acknowledgments. A typical NB-IoT NPRACH overhead is in the order of 5 %.* |
| 5.2.3.2.4.3 | *Variable bit rate capabilities:* Describe how the proposal supports different applications and services with various bit rate requirements.***For NR and LTE component RIT:****For a given combination of modulation scheme, code rate, and number of spatial-multiplexing layers, the data rate available to a user can be controlled by the scheduler by assigning different number of resource blocks for the transmission. In case of multiple services, the available/assigned resource, and thus the available data rate, is shared between the services.* |
| 5.2.3.2.4.4 | *Variable payload capabilities:*Describe how the RIT/SRIT supports IP-based application layer protocols/services (e.g., VoIP, video-streaming, interactive gaming, etc.) with variable-size payloads.*See also 5.2.3.2.4.3.****For NR component RIT:****The transport-block size can vary between X bits and Y bits. The number of bits per transport block can be set with a fine granularity.**See [38.214] sub-clause 5.1.3.2 for details.****For LTE component RIT:****The transport-block size can vary between 16 bits and 2\*391656 bits. The number of bits per transport block can be assigned with a fine granularity.**For eMTC, the maximum transport block size is 1000 bits in both UL and DL(optionally 2984 bits) for the lowest UE category dedicated to eMTC and 4008 bits and 6968 bits for DL and UL respectively for the highest UE category dedicated to eMTC.**See [36.213] sub-clause 7.1.7.2.1 for details.**For NB-IoT, the maximum transport block size is 680 bits in the DL and 1000 bits in UL for the lowest UE category and 2536 bits for both DL and UL for the highest UE category.**See [36.213] sub-clause 16.4.1.5.1 for details.* |
| 5.2.3.2.4.5 | *Signalling transmission scheme:*Describe how transmission schemes are different for signalling/control from that of user data.***For NR component RIT:**** ***Downlink***

*L1/L2 control signalling is transmitted in assigned resources time and frequency multiplexed with data within the bandwidth part (BWP, see item 5.2.3.2.8.1). Control signalling is limited to QPSK modulation (QPSK, 16QAM, 64QAM and 256QAM for data). Control signalling error correcting codes are polar codes (LDPC codes for data).** ***Uplink***

*L1/L2 control signalling transmitted in assigned resources and can be time and frequency multiplexed with data within the BWP. L1/L2 control signalling can also be multiplexed with data on the PUSCH. Modulation schemes for L1/L2 control signalling is π/2-BPSK, BPSK and QPSK**Control signalling error correcting codes are block codes for small payload and polar codes for larger payloads (LDPC codes for data).* *For both downlink and uplink, higher-layer signalling (e.g. MAC, RLC, PDCP headers and RRC signalling) is carried within transport blocks and thus transmitted using the same physical-layer transmitter processing as user data.****For LTE component RIT:**** ***Downlink***

*L1/L2 control signalling is time-multiplexed with data and transmitted in the first up to three OFDM symbols of each subframe.* *In case of short TTI, the L1/L2 control signaling can be both time and frequency multiplexed with data and transmitted in the associated short TTI. Control signalling is not confined to a certain set of resource blocks but is spread over the overall system bandwidths. Control signalling is limited to QPSK modulation (QPSK, 16QAM, and 64QAM for data). Control signalling relies on tail-biting convolutional coding. Turbo-codes are used for data with the exception for NB-IoT where also data transmission uses tail-biting convolutional coding. In case of eMTC and NB-IoT the L1/L2 control signaling can be time multiplexed with data and are transmitted in scheduled subframes.** ***Uplink***

*L1/L2 control signalling transmitted in one or multiple resource blocks typically at the edge of the system bandwidth and frequency multiplexed with data. For NB-IoT the L1 control signaling is time and frequency multiplexed with data.* *For both downlink and uplink, higher-layer signalling (e.g. MAC, RLC, PDCP headers and RRC signalling) is carried within transport blocks and thus transmitted using the same physical-layer transmitter processing as user data.* |
| 5.2.3.2.4.6 | *Small signalling overhead*Signalling overhead refers to the radio resource that is required by the signalling divided by the total radio resource which is used to complete a transmission of a packet. The signalling includes necessary messages exchanged in DL and UL directions during a signalling mechanism, and Layer 2 protocol header for the data packet.Describe how the RIT/SRIT supports efficient mechanism to provide small signalling overhead in case of small packet transmissions.***For NR component RIT:****The information will be provided in later update.****For LTE component RIT:****In case of small data packet transmission, the L1/L2 control signalling during the connection setup procedure is dominating the uplink and downlink transmissions. To minimize this overhead LTE, including NB-IoT, allows a UE to resume of an earlier connection. As an alternative, the data can be transmitted over the control plane, which eliminates the need to setup the data plane connection.*  |
| **5.2.3.2.5** | **Mobility management (Handover)** |
| 5.2.3.2.5.1 | Describe the handover mechanisms and procedures which are associated with – Inter-System handover including the ability to support mobility between theRIT/SRIT and at least one other IMT system– Intra-System handover 1 Intra-frequency and Inter-frequency 2 Within the RIT or between component RITs within one SRIT (if applicable)Characterize the type of handover strategy or strategies (for example, UE or base station assisted handover, type of handover measurements).What other IMT system (other than IMT-2020) could be supported by the handover mechanism?***Terminology:****To ease understanding of specific terms/abbreviations used in this item here after, few main acronyms and definitions are introduced:** *NR: NR Radio Access*
* *NG-RAN: NG Radio Access Network (connected to 5GC; it may use the E-UTRA or NR radio access)*
* *5GC: 5G Core Network*
* *gNB, NG-RAN node providing NR user and control plane terminations towards the UE;*
* *ng-eNB: NG-RAN node providing E-UTRA user and control plane terminations to the UE*
* *en-gNB: NG-RAN node providing NR user plane and control plane protocol terminations towards the UE, and acting as Secondary Node in EN-DC.*
* *eNB: E-UTRAN node, connecting to EPC*
* *MN: Master Node*
* *SN: Secondary Node*
* *MR-DC: Multi-RAT Dual Connectivity*
* *NE-DC: NR-E-UTRA Dual Connectivity (connected to EPC)*
* *EN-DC: E-UTRA-NR Dual Connectivity (connected to EPC)*
* *NGEN-DC: NG-RAN E-UTRA-NR Dual Connectivity (Connected to 5GC)*

***Inter-System handover:*** *Inter-system handover is supported between 5G Core Network (5GC) and EPC.* *- Handover between NR in 5GC and E-UTRA in EPC is supported via inter-RAT handover.* *- Handover between E-UTRA in 5GC and E-UTRA in EPC is supported via intra-E-UTRA handover with change of CN type.* *The source eNB/ng-eNB decides handover procedure to trigger (e.g. via the same CN type or to the other CN type). UE has to know the target CN type from the handover command during intra-LTE inter-system HO, intra-LTE intra-system HO.****Intra-System handover:******For NR component RIT****:**1) Intra-NR handover: Network controlled mobility applies to UEs in RRC\_CONNECTED and is categorized into two types of mobility:* * *Cell level mobility requires explicit RRC signalling to be triggered, i.e. handover. For inter-gNB handover, handover request, handover acknowledgement, handover command, handover complete procedure are supported between source gNB and target gNB. The release of the resources at the source gNB during the handover completion phase is triggered by the target gNB.*
* *Beam level mobility does not require explicit RRC signalling to be triggered - it is dealt with at lower layers - and RRC is not required to know which beam is being used at a given point in time.*

*Data forwarding, in-sequence delivery and duplication avoidance at handover can be guaranteed between target gNB and source gNB.**2) Inter-RAT handover: Intra 5GC inter RAT mobility is supported between NR and E-UTRA. Inter RAT measurements in NR are limited to E-UTRA and the source RAT should be able to support and configure Target RAT measurement and reporting. The in-sequence and lossless handover is supported for the handover between gNB and ng-eNB. Both Xn and NG based inter-RAT handover between NG-RAN nodes is supported. Whether the handover is over Xn or CN is transparent to the UE. The target RAT receives the UE NG-C context information and based on this information configures the UE with a complete RRC message and Full configuration (not delta).**Measurement* *In RRC\_CONNECTED, the UE measures multiple beams (at least one) of a cell and the measurements results (power values) are averaged to derive the cell quality. In doing so, the UE is configured to consider a subset of the detected beams: the N best beams above an absolute threshold. Filtering takes place at two different levels: at the physical layer to derive beam quality and then at RRC level to derive cell quality from multiple beams. Cell quality from beam measurements is derived in the same way for the serving cell(s) and for the non-serving cell(s). Measurement reports may contain the measurement results of the X best beams if the UE is configured to do so by the gNB.**For more details, refer to [38.300] sub-clauses 9.2.3 & 9.3****For LTE component RIT****:**In E-UTRAN RRC\_CONNECTED state, network-controlled UE-assisted handovers and DC specific activities are performed and various DRX cycles are supported.**Handover procedures, like processes that precede the final HO decision on the source network side (control and evaluation of UE and eNB measurements taking into account certain UE specific roaming and access restrictions), preparation of resources on the target network side, commanding the UE to the new radio resources and finally releasing resources on the (old) source network side. It contains mechanisms to transfer context data between evolved nodes, and to update node relations on C-plane and U-plane.**Measurement**Measurements to be performed by a UE for intra/inter-frequency mobility can be controlled by E-UTRAN, using broadcast or dedicated control. In RRC\_IDLE state, a UE shall follow the measurement parameters defined for cell reselection specified by the E-UTRAN broadcast. The use of dedicated measurement control for RRC\_IDLE state is possible through the provision of UE specific priorities. In RRC\_CONNECTED state, a UE shall follow the measurement configurations specified by RRC directed from the E-UTRAN (e.g. as in UTRAN MEASUREMENT\_CONTROL).**In RRC\_IDLE and RRC\_CONNECTED the UE may be configured to monitor some UTRA or E-UTRA carriers according to reduced performance requirements as specified in [36.133].**For CSI-RS based discovery signals measurements, "cell" should be interpreted as "transmission point of the concerned cell" in the following descriptions.**Intra-frequency neighbour (cell) measurements and inter-frequency neighbour (cell) measurements are defined as follows:** *Intra-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are intra-frequency measurements when the current and target cell operates on the same carrier frequency.*
* *Inter-frequency neighbour (cell) measurements: Neighbour cell measurements performed by the UE are inter-frequency measurements when the neighbour cell operates on a different carrier frequency, compared to the current cell.*

*For more details, refer to [36.300] sub-clauses 10.1 & 10.2* |
| 5.2.3.2.5.2 | Describe the handover mechanisms and procedures to meet the simultaneous handover requirements of a large number of users in high speed scenarios (up to 500km/h moving speed) with high handover success rate.*The information will be provided in later update.* |
| **5.2.3.2.6** | **Radio resource management**  |
| 5.2.3.2.6.1 | Describe the radio resource management, for example support of:– centralised and/or distributed RRM– dynamic and flexible radio resource management– efficient load balancing.*RRM mechanism in the following is supported in both LTE and NR component RIT commonly.**General LTE/NR performs radio resource management to ensure the efficient use of the available radio resource. RRM functions include:** *Radio bearer control (RBC): the establishment, maintenance and release of radio bearer involves the configuration of radio resource. This is located in gNB/ng-eNB.*
* *Radio Admission Control (RAC): RAC is to admit or reject the establishment of new radio bearer. It considers QoS requirement, the priority level, overall resource situation. This is located in gNB/ng-eNB.*
* *Connection Mobility Control (CMC): it controls the number of UEs in idle mode and connected mode. In idle mode, cell reselection algorithm is controlled by parameter setting and in the connected mode, gNB controls UE mobility via handover and RRC connection release with redirection.*

*Dynamic/flexible radio resource management**LTE/NR supports dynamic and flexible radio resource management by packet scheduling that allocates and de-allocates resources to user and control plane packets.* *Load balancing(LB)**Load balancing has the task to handle uneven distribution of the traffic load over multiple cells. The purpose of LB is thus to influence the load distribution for the higher resource utilization and QoS. LB is achieved in NR with hand-over, redirection or cell reselection.*  |
| 5.2.3.2.6.2 | *Inter-RIT interworking*Describe the functional blocks and mechanisms for interworking (such as a network architecture model) between component RITs within a SRIT, if supported.***Multi-RAT Dual Connectivity:*** *Tight inter-working between E-UTRA and NR is supported with Multi-RAT Dual Connectivity (MR-DC) operation using E-UTRA and NR. The following type of MR-DC is supported:** *MR-DC with the EPC: E-UTRA-NR Dual Connectivity (EN-DC). eNB is master node (MN) and gNB is acting as secondary node (SN)*
* *MR-DC with the 5GC:*
	+ *NG-RAN E-UTRA-NR Dual Connectivity (NGEN-DC): eNB is MN and gNB is SN.*
	+ *NR-E-UTRA Dual Connectivity (NE-DC): gNB is MN and eNB is SN.*

*Similar to LTE dual connectivity, MN is responsible for handover and SN provides offloading to increase overall data rate.* *Control plane architecture: For MR-DC operation, eNB and gNB is communicated via X2-C interface for EN-DC and Xn-C for MR-DC with the 5GC. Single RRC state is maintained but both MN and SN has two RRC entities and can generate full RRC messages.* *User plane architecture: MR-DC supports MCG, SCG and split bearer. In case of split bearer, both MN and SN support RLC for the same radio bearer.* *For more details, refer to [37.340]; see also item 5.2.3.2.13.1* |
| 5.2.3.2.6.3 | *Connection/session management*The mechanisms for connection/session management over the air-interface should be described. For example:– The support of multiple protocol states with fast and dynamic transitions. – The signalling schemes for allocating and releasing resources. *NG-RAN support the following states:* ***RRC\_IDLE****:**- PLMN selection;**- Broadcast of system information;**- Cell re-selection mobility;**- Paging for mobile terminated data is initiated by 5GC;**- Paging for mobile terminated data area is managed by 5GC;**- DRX for CN paging configured by NAS.**-* ***RRC\_INACTIVE****:**- Broadcast of system information;**- Cell re-selection mobility;**- Paging is initiated by NG-RAN (RAN paging);**- RAN-based notification area (RNA) is managed by NG- RAN;**- DRX for RAN paging configured by NG-RAN;**- 5GC - NG-RAN connection (both C/U-planes) is established for UE;**- The UE AS context is stored in NG-RAN and the UE;**- NG-RAN knows the RNA which the UE belongs to.**-* ***RRC\_CONNECTED****:**- 5GC - NG-RAN connection (both C/U-planes) is established for UE;**- The UE AS context is stored in NG-RAN and the UE;**- NG-RAN knows the cell which the UE belongs to;**- Transfer of unicast data to/from the UE;**- Network controlled mobility including measurements.**Transition between RRC states:** *From RRC\_IDLE to RRC\_CONNECTED: RRC connection setup*
* *From RRC\_CONNECTED to RRC\_IDLE: RRC connection release*
* *From RRC\_INACTIVE to RRC\_CONNECTED: RRC connection resume*
* *From RRC\_CONNECTED to RRC\_INACTIVE: RRC connection suspension*
* *From RRC\_INACTIVE to RRC\_IDLE: RRC connection release (TBC)*
* *From RRC\_IDLE to RRC\_INACTIVE: not supported*

*For more details, refer to [38.300]* |
| **5.2.3.2.7** | **Frame structure** |
| 5.2.3.2.7.1 | Describe the frame structure for downlink and uplink by providing sufficient information such as:– frame length,– the number of time slots per frame,– the number and position of switch points per frame for TDD– guard time or the number of guard bits,– user payload information per time slot,– sub-carrier spacing – control channel structure and multiplexing,– power control bit rate.***For NR component RIT:**** ***Frame length, sub-carrier spacing, and time slots:***

*One radio frame of length 10 ms consisting of 10 subframes, each of length 1 ms. Each subframe consists of an OFDM sub-carrier spacing dependent number of slots. Each slot consists of 14 OFDM symbols (twelve OFDM symbols in case of extended cyclic prefix)** *15 kHz SCS: 1 ms slot, 1 slot per sub-frame*
* *30 kHz SCS: 0.5 ms slot, 2 slots per sub-frame*
* *60 kHz SCS: 0.25 ms slot, 4 slots per sub-frame*
* *120 kHz SCS: 0.125 ms slot, 8 slots per sub-frame*
* *240 kHz SCS: 0.0625 ms slot (only used for synchronization, not for data)*

*Data transmissions can be scheduled on a slot basis, as well as on a partial slot basis, where the partial slot transmissions that may occur several times within one slot. The supported partial slot allocations and scheduling intervals are 2, 4 and 7 symbols for normal cyclic prefix, and 2, 4 and 6 symbols for extended cyclic prefix.**The slot structure supports zero, one or two DL/UL switches per slot, and dynamic selection of the link direction for each slot independently. Typically one symbol would be allocated as guard, but different number of symbols, or even full slot could be allocated as guard.** ***Downlink control channel structure:***

*Downlink control signaling is time and frequency multiplexed with data on a scheduling interval basis. The control region can span over 1-3 OFDM symbols in the beginning of the allocation, flexibly allocating 1-14 symbols for data transmission, including the time and frequency part of the control region that was not used for control signaling.** ***Uplink control channel structure:***

*Uplink control signaling can be both time-multiplexed with the data of the same UE and time and frequency multiplexed with control and data of other UEs when the UE has no data to be transmitted. Uplink control signaling is piggy-backed with data i.e. transmitted with data on the PUSCH when the UE has data to be transmitted.** ***Power control bit rate:***

*No specific power-control rate is defined, but a power control command can be sent at any slot, leading to a sub-carrier spacing specific maximum power control rate of 1/2/4/8 kHz for SCS of 15/30/60/120 kHz respectively.****For LTE component RIT:**** ***Frame length, sub-carrier spacing, and time slots:***

*Both FDD and TDD frame structures are supported. One radio frame of length 10 ms consisting of 10 subframes, each of length 1 ms. Each subframe consists of two slots, each of length 0.5 ms. Each slot consists of seven OFDM symbols (six OFDM symbols in case of extended cyclic prefix). A minimum time unit for transmission is either a TTI, which has a duration of one subframe, or a short TTI, having a duration of one slot (with FDD and TDD) or 2/3 OFDM symbols (only with FDD). Sub-carrier spacings of 15kHz is supported for uni-cast data and subcarrier spacings of 15kHz, 7.5kHz and 1.25kHz are supported for multi-cast data.**For the frame structure of TDD, it is possible to have two DL/UL switching points (one downlink part and one uplink part) or four DL/UL switching points (two downlink parts and two uplink parts) per frame. Switching downlink to uplink takes place in a special subframe which consists of the three fields DwPTS, GP and UpPTS, see [36.211] subclause 4.2.**The guard time can be flexibly configured from a minimum of approximately 70 s to a maximum of approximately 700 s in case of TDD.**For NB-IoT, the minimum time unit for transmission is a subframe in the downlink and a resource unit in the uplink. The length of a resource unit is dependent on the subcarrier spacing and number of subcarriers. Up to ten subframes or resource units can be assigned to the UE for one transmission. Sub-carrier spacings of 15kHz is supported for DL, and sub-carrier spacings of 3.75kHz and 15kHz is supported for UL (see item 5.2.3.2.2.1 for more details).**For eMTC half-duplex FDD operation and NB-IoT, a guard period of 1ms is used for the switching time.**For more details on the frame structure including DL/UL switching and guard times in case of TDD operation., see [36.211] sub-clause 4.** ***Downlink control channel structure:***

*Downlink control signalling can be either time or time and frequency multiplexed with data on a subframe TTI or short TTI basis. With time multiplexing, control signaling is transmitted in the first up to three OFDM symbols of each subframe and data transmitted in the remaining part of the subframe (up to 13 OFDM symbols).* *For eMTC and NB-IoT, downlink control signalling and data transmission to the same UE are time multiplexed on different subframes.* * ***Uplink control channel structure:***

*Uplink control signalling is frequency-multiplexed with data for other UEs (no time separation) when the UE has no data to be transmitted. Uplink control signalling is typically transmitted at the edges of the overall system bandwidth. Uplink control signalling is piggy-backed with data i.e. transmitted with data on the PUSCH when the UE has data to be transmitted.** ***Power control bit rate:***

*There is no specific power-control rate. At most one power-control command per subframe, implying 1 kHz maximum power-control rate.**For more details on the (uplink) power control, see [36.213] sub-clause 5.1.**For NB-IoT, only open-loop power control is supported.* |
| **5.2.3.2.8** | **Spectrum capabilities and duplex technologies**NOTE 1 – Parameters for both downlink and uplink should be described separately, if necessary. |
| 5.2.3.2.8.1 | *Spectrum sharing and flexible spectrum use*Does the RIT/SRIT support flexible spectrum use and/or spectrum sharing? Provide the detail.Description such as capability to flexibly allocate the spectrum resources in an adaptive manner for paired and un-paired spectrum to address the uplink and downlink traffic asymmetry. ***For NR component RIT:**** *NR supports flexible spectrum use through mechanisms including the following:*
* *Multiple component carriers can be aggregated to achieve up to 6.4 GHz of transmission bandwidth. The aggregated component carriers can be either contiguous or non-contiguous in the frequency domain, including be located in separate spectrum (“spectrum aggregation”).*
* *In addition, within one component carrier, bandwidth part (BWP) is supported on downlink and uplink. The bandwidth of the component carrier can be divided into several bandwidth parts. From network perspective, different bandwidth parts can be associated with different numerologies (subcarrier spacing, cyclic prefix). UEs with smaller bandwidth support capability can work within a bandwidth part with an associated numerology. By this means UEs with different bandwidth support capability can work on large bandwidth component carrier. NR supports UE bandwidth part adaptation for UE power saving and numerology switching. The network can operate on a wide bandwidth carrier while it is not required for the UE to support the whole bandwidth carrier, but can work over activated bandwidth parts, thereby optimizing the use of radio resources to the traffic demand and minimizing interference to/from other systems.*
* *NR supports spectrum sharing with LTE. The operating carrier of NR and LTE can be overlapped or adjacent. From network perspective, NR users and LTE users can share / co-exist on the overlapped carrier in frequency division multiplexing (FDM) or time division multiplexing (TDM) manner, with dynamic scheduling or semi-static configurations. When LTE and NR spectrum overlaps, resources can be shared by LTE DL carrier and NR DL carrier, or by LTE UL carrier and NR UL carrier. OFDM symbol durations of NR and LTE can be aligned. The system allows aligning sub-carriers of LTE and NR to enable more efficient sharing of overlapped resources.*
* *NR addresses the uplink and downlink traffic asymmetry with flexible spectrum resource allocation by allowing FDD operation on a paired spectrum, different transmission directions in either part of a paired spectrum, TDD operation on an unpaired spectrum where the transmission direction of time resources is not dynamically changed, and TDD operation on an unpaired spectrum where the transmission direction of most time resources can be dynamically changing. DL and UL transmission directions for data can be dynamically assigned on a per-slot basis.*

***For LTE component RIT:**** *LTE supports flexible spectrum use by using one or multiple component carriers. Multiple component carriers can be aggregated to achieve up to 640 MHz of transmission bandwidth. The aggregated component carriers can be either contiguous or non-contiguous in the frequency domain, including be located in separate spectrum (“spectrum aggregation”).*
* *LTE addresses the uplink and downlink traffic asymmetry with flexible allocating spectrum resources by allowing TDD operation on an unpaired spectrum where the transmission direction of time resources is not dynamically changed, and TDD operation on an unpaired spectrum where the transmission direction of most time resources can be changing among the seven DL/UL configurations per as low as radio frame basis.*

*For NB-IoT,** *Flexible spectrum use is supported by using one or multiple NB-IoT carriers.*
	+ *A single, anchor, NB-IoT carrier of 180 kHz each for UL and DL in FDD is the minimum required spectrum.*
	+ *Additional non-anchor NB-IoT carrier(s), each of 180 kHz can be associated to the same NB-IoT cell, and a UE uses either the anchor or one non-anchor NB-IoT carrier.*
	+ *The anchor carrier and non-anchor carrier(s) can be either contiguous or non-contiguous in the frequency domain.*
* *An NB-IoT carrier can be in-band with LTE, in an LTE guard-band, or in spectrum where no LTE is present. These are termed in-band, guard-band, and standalone operation respectively.*

*For eMTC, there is no aggregation of multiple component carriers.* |
| 5.2.3.2.8.2 | *Channel bandwidth scalability* Describe how the proposed RIT/SRIT supports channel bandwidth scalability, including the supported bandwidths. Describe whether the proposed RIT/SRIT supports extensions for scalable bandwidths wider than 100 MHz.Describe whether the proposed RIT/SRIT supports extensions for scalable bandwidths wider than 1 GHz, e.g., when operated in higher frequency bands noted in § 5.2.4.2.Consider, for example:– The scalability of operating bandwidths. – The scalability using single and/or multiple RF carriers.Describe multiple contiguous (or non-contiguous) band aggregation capabilities, if any. Consider for example the aggregation of multiple channels to support higher user bit rates.***For NR component RIT:****One component carrier supports a scalable bandwidth, 5, 10, 15, 20, 25, 40, 50, 60, 80, 100MHz for frequency range 450 MHz to 6000 MHz (see [38.101] for the actual support of bandwidth for each band), with guard band ratio from 20% to 2%; and a scalable bandwidth, 50, 100, 200, 400MHz for frequency range 24250 – 52600 MHz (see [38.101] for the actual support of bandwidth for each band), with guard band ratio from 8% to 5%. By aggregating multiple component carriers, transmission bandwidths up to 6.4 GHz are supported to provide high data rates. Component carriers can be either contiguous or non-contiguous in the frequency domain. The number of component carriers transmitted and/or received by a mobile terminal can vary over time depending on the instantaneous data rate.* ***For LTE component RIT:****One component carrier supports a scalable bandwidth, 1.4, 3, 5, 10, 15 and 20 MHz, with guard band ratio from 23% to 10% (see [36.101] sub-clause 5.6 for more details). By aggregating multiple component carriers, transmission bandwidths up to 640 MHz are supported to provide the high data rates. Component carriers can be either contiguous or non-contiguous in the frequency domain. The number of component carriers transmitted and/or received by a mobile terminal can vary over time depending on the instantaneous data rate.**For NB-IoT, the channel bandwidth is not scalable. There is not aggregation of multiple NB-IoT carriers – see item 5.2.3.2.8.1 for more details.**For eMTC, the above scalable bandwidth from 1.4 to 20 MHz is supported. The eMTC UE can have a narrower RF bandwidth than the cell is configured with. Category M1 UE has a bandwidth of 1.4 MHz, and category M2 UE has 5 MHz.* |
| 5.2.3.2.8.3 | What are the frequency bands supported by the RIT/SRIT? Please list.***For NR component RIT:****The following frequency bands will be supported, in accordance with spectrum requirements defined by Report ITU-R M.2411-0. Introduction of other ITU-R IMT identified bands are not precluded in the future. 3GPP technologies are also defined as appropriate to operate in other frequency arrangements and bands.**450 – 6000 MHz:*

|  |  |  |
| --- | --- | --- |
| **Band number** | **UL operating band** | **DL operating band** |
| n1 | 1920 – 1980 MHz | 2110 – 2170 MHz |
| n2 | 1850 – 1910 MHz | 1930 – 1990 MHz |
| n3 | 1710 – 1785 MHz | 1805 – 1880 MHz |
| n5 | 824 – 849 MHz | 869 – 894MHz |
| n7 | 2500 – 2570 MHz | 2620 – 2690 MHz |
| n8 | 880 – 915 MHz | 925 – 960 MHz |
| n20 | 832 – 862 MHz | 791– 821MHz |
| n28 | 703 – 748 MHz | 758 – 803 MHz |
| n38 | 2570 – 2620 MHz | 2570 – 2620 MHz |
| n41 | 2496 – 2690 MHz | 2496 – 2690 MHz |
| n50 | 1432 – 1517 MHz | 1432 – 1517 MHz |
| n51 | 1427 – 1432 MHz | 1427 – 1432 MHz |
| n66 | 1710 – 1780 MHz | 2110 – 2200 MHz |
| n70 | 1695 – 1710 MHz | 1995– 2020 MHz |
| n71 | 663 – 698 MHz | 617 – 652 MHz |
| n74 | 1427 –1470 MHz | 1475 – 1518 MHz |
| n75 | N/A | 1432 – 1517 MHz |
| n76 | N/A | 1427 – 1432 MHz |
| n77 | 3.3 – 4.2 GHz | 3.3 – 4.2 GHz |
| n78 | 3.3 – 3.8 GHz | 3.3 – 3.8 GHz |
| n79 | 4.4 – 5.0 GHz | 4.4 – 5.0 GHz |
| n80 | 1710 – 1785 MHz | N/A |
| n81 | 880 – 915 MHz | N/A |
| n82 | 832 – 862 MHz | N/A |
| n83 | 703 – 748 MHz | N/A |
| n84 | 1920 – 1980 MHz | N/A |
| n85 | 2496 – 2690 MHz | N/A |

*24250 – 52600 MHz:*

|  |  |  |
| --- | --- | --- |
| **Band number** |  **UL operating band** | **DL operating band** |
| n257 | 26.5 –29.5 GHz | 26.5 –29.5 GHz |
| n258 | 24.25 – 27.5 GHz | 24.25 – 27.5 GHz |
| n260 | 37–40 GHz | 37–40 GHz |

***For LTE component RIT:****The following frequency bands are currently specified, in accordance with spectrum requirements defined by Report ITU-R M.2411-0. Introduction of other ITU-R IMT identified bands are not precluded in the future. 3GPP technologies are also defined as appropriate to operate in other frequency arrangements and bands. Detailed information on the following bands can be found in [36.101] sub-clause 5.5.**450 – 6000 MHz:*

|  |  |  |
| --- | --- | --- |
| Band number | UL operating band | DL operating band |
| 1 | 1920 MHz | – | 1980 MHz  | 2110 MHz | – | 2170 MHz |
| 2 | 1850 MHz | – | 1910 MHz | 1930 MHz | – | 1990 MHz |
| 3 | 1710 MHz | – | 1785 MHz | 1805 MHz | – | 1880 MHz |
| 4 | 1710 MHz | – | 1755 MHz  | 2110 MHz | – | 2155 MHz |
| 5 | 824 MHz | – | 849 MHz | 869 MHz | – | 894MHz |
| 6 | 830 MHz | – | 840 MHz | 875 MHz | – | 885 MHz |
| 7 | 2500 MHz | – | 2570 MHz | 2620 MHz | – | 2690 MHz |
| 8 | 880 MHz | – | 915 MHz | 925 MHz | – | 960 MHz |
| 9 | 1749.9 MHz | – | 1784.9 MHz | 1844.9 MHz | – | 1879.9 MHz |
| 10 | 1710 MHz | – | 1770 MHz | 2110 MHz | – | 2170 MHz |
| 11 | 1427.9 MHz | – | 1447.9 MHz  | 1475.9 MHz | – | 1495.9 MHz  |
| 12 | 699 MHz | – | 716 MHz | 729 MHz | – | 746 MHz |
| 13 | 777 MHz | – | 787 MHz | 746 MHz | – | 756 MHz |
| 14 | 788 MHz | – | 798 MHz | 758 MHz | – | 768 MHz |
| 17 | 704 MHz | – | 716 MHz | 734 MHz | – | 746 MHz |
| 18 | 815 MHz | – | 830 MHz | 860 MHz | – | 875 MHz |
| 19 | 830 MHz | – | 845 MHz | 875 MHz | – | 890 MHz |
| 20 | 832 MHz | – | 862 MHz | 791 MHz | – | 821 MHz |
| 21 | 1447.9 MHz | – | 1462.9 MHz | 1495.9 MHz | – | 1510.9 MHz |
| 22 | 3410 MHz | – | 3490 MHz | 3510 MHz | – | 3590 MHz |
| 23 | 2000 MHz | – | 2020 MHz | 2180 MHz | – | 2200 MHz |
| 24 | 1626.5 MHz | – | 1660.5 MHz | 1525 MHz | – | 1559 MHz |
| 25 | 1850 MHz | – | 1915 MHz | 1930 MHz | – | 1995 MHz |
| 26 | 814 MHz | – | 849 MHz | 859 MHz | – | 894 MHz |
| 27 | 807 MHz | – | 824 MHz | 852 MHz | – | 869 MHz |
| 28 | 703 MHz | – | 748 MHz | 758 MHz | – | 803 MHz |
| 29 | N/A | 717 MHz | – | 728 MHz |
| 30 | 2305 MHz | – | 2315 MHz | 2350 MHz | – | 2360 MHz |
| 31 | 452.5 MHz | – | 457.5 MHz | 462.5 MHz | – | 467.5 MHz |
| 32 |  | N/A |  | 1452 MHz | – | 1496 MHz |
| 33 | 1900 MHz | – | 1920 MHz | 1900 MHz | – | 1920 MHz |
| 34 | 2010 MHz | – | 2025 MHz  | 2010 MHz | – | 2025 MHz |
| 35 | 1850 MHz | – | 1910 MHz | 1850 MHz | – | 1910 MHz |
| 36 | 1930 MHz | – | 1990 MHz | 1930 MHz | – | 1990 MHz |
| 37 | 1910 MHz | – | 1930 MHz | 1910 MHz | – | 1930 MHz |
| 38 | 2570 MHz | – | 2620 MHz | 2570 MHz | – | 2620 MHz |
| 39 | 1880 MHz | – | 1920 MHz | 1880 MHz | – | 1920 MHz |
| 40 | 2300 MHz | – | 2400 MHz | 2300 MHz | – | 2400 MHz |
| 41 | 2496 MHz |  | 2690 MHz | 2496 MHz |  | 2690 MHz |
| 42 | 3400 MHz | – | 3600 MHz | 3400 MHz | – | 3600 MHz |
| 43 | 3600 MHz | – | 3800 MHz | 3600 MHz | – | 3800 MHz |
| 44 | 703 MHz | – | 803 MHz | 703 MHz | – | 803 MHz |
| 45 | 1447 MHz | – | 1467 MHz | 1447 MHz | – | 1467 MHz |
| 48 | 3550 MHz | – | 3700 MHz | 3550 MHz | – | 3700 MHz |
| 50 | 1432 MHz | - | 1517 MHz | 1432 MHz | - | 1517 MHz |
| 51 | 1427 MHz | - | 1432 MHz | 1427 MHz | - | 1432 MHz |
| 65 | 1920 MHz | – | 2010 MHz  | 2110 MHz | – | 2200 MHz |
| 66 | 1710 MHz | – | 1780 MHz  | 2110 MHz | – | 2200 MHz |
| 67 |  | N/A |  | 738 MHz | – | 758 MHz |
| 68 | 698 MHz | – | 728 MHz  | 753 MHz | – | 783 MHz  |
| 69 |  | N/A |  | 2570 MHz  | – | 2620 MHz |
| 70 | 1695 MHz | – | 1710 MHz  | 1995 MHz | – | 2020 MHz |
| 71 | 663 MHz | – | 698 MHz  | 617 MHz | – | 652 MHz |
| 72 | 451 MHz | – | 456 MHz  | 461 MHz | – | 466 MHz |
| 74 | 1427 MHz | – | 1470 MHz  | 1475 MHz | – | 1518 MHz  |
| 75 |  | N/A |  | 1432 MHz | – | 1517 MHz |
| 76 |  | N/A |  | 1427 MHz | – | 1432 MHz |

*For NB-IoT, Category NB1 and NB2 are designed to operate in band 1, 2, 3, 4, 5, 8, 11, 12, 13, 17, 18, 19, 20, 21, 25, 26, 28, 31, 41, 66, 70, 71, 72 and 74 in the above table. See more details in [36.101] sub-clause 5.5F.**For eMTC, UE category M1 and M2 is designed to operate in band 1, 2, 3, 4, 5, 7, 8, 11, 12, 13, 14, 18, 19, 20, 21, 25, 26, 27, 28, 31, 39, 40, 41, 66, 71, 72 and 74 in the above table. See more details in [36.101] sub-clause 5.5E.**For V2X communication, the bands can be found in [36.101] sub-clause 5.5G.* |
| 5.2.3.2.8.4 | What is the minimum amount of spectrum required to deploy a contiguous network, including guardbands (MHz)? ***For NR component RIT:****The minimum amount of paired spectrum is 2 x 5 MHz. The minimum amount of unpaired spectrum is 5 MHz.* ***For LTE component RIT:****The minimum amount of paired spectrum is 2 x 1.4 MHz, and the minimum amount of unpaired spectrum is 1.4 MHz, except for NB-IoT.**For NB-IoT, the minimum amount of spectrum is 0.2 MHz.* |
| 5.2.3.2.8.5 | What are the minimum and maximum transmission bandwidth (MHz) measured at the 3 dB down points?***For NR component RIT:****The 3 dB bandwidth is not part of the specifications, however:** *The minimum 99% channel bandwidth (occupied bandwidth of single component carrier) is*
	+ *5 MHz for frequency range 450 – 6000 MHz;*
	+ *50 MHz for frequency range 24250 – 52600 MHz*
* *The maximum 99% channel bandwidth (occupied bandwidth of single component carrier) is*
	+ *100 MHz for frequency range 450 – 6000 MHz;*
	+ *400 MHz for frequency range 24250 – 52600 MHz.*
* *Multiple component carriers can be aggregated to achieve up to 6.4 GHz of transmission bandwidth.*

***For LTE component RIT:****The 3 dB bandwidth is not part of the specifications, however:** *The minimum 99% channel bandwidth (occupied bandwidth of single component carrier) is 1.4 MHz.*
* *The maximum 99% channel bandwidth (occupied bandwidth of single component carrier) is 20 MHz.*
* *Multiple component carriers can be aggregated to achieve up to 640 MHz of transmission bandwidth.*

*For NB-IoT, the minimum 99% channel bandwidth is 0.2 MHz.* |
| 5.2.3.2.8.6 | What duplexing scheme(s) is (are) described in this template? (e.g. TDD, FDD or half-duplex FDD). Provide the description such as:– What duplexing scheme(s) can be applied to paired spectrum? Provide the details (see below as some examples).– What duplexing scheme(s) can be applied to un-paired spectrum? Provide the details (see below as some examples).Describe details such as:– What is the minimum (up/down) frequency separation in case of full- and half-duplex FDD? – What is the requirement of transmit/receive isolation in case of full- an half-duplex FDD? Does the RIT require a duplexer in either the UE or base station? – What is the minimum (up/down) time separation in case of TDD?– Whether the DL/UL ratio variable for TDD? What is the DL/UL ratio supported? If the DL/UL ratio for TDD is variable, what would be the coexistence criteria for adjacent cells?***For NR component RIT:****NR supports paired and unpaired spectrum and allows FDD operation on a paired spectrum, different transmission directions in either part of a paired spectrum, TDD operation on an unpaired spectrum where the transmission direction of time resources is not dynamically changed, and TDD operation on an unpaired spectrum where the transmission direction of most time resources can be dynamically changing. DL and UL transmission directions for data can be dynamically assigned on a per-slot basis.** *For FDD operation, it supports full-duplex FDD.*
	+ *For both base station and terminal, a duplexer is needed for full-duplex FDD.*
* *For full-duplex FDD, the required transmit/receive isolation is a UE function of; the Tx emission mask (emission level on the Rx frequency) , the TX-Rx frequency spacing , the Tx- Rx duplex filter isolation, the TX and RX configuration (RB location, RB power and RB allocation) and the required Rx desense criteria. For the supported operating bands, the parameters including the minimum (up/down) Tx to Rx frequency separation and the minimum Tx-Rx band gap are being defined in 3GPP.*
* *For different transmission directions in either part of a paired spectrum, a duplexer is needed for both base station and the terminal. The required frequency separation between the paired spectrum is the same as full-duplex FDD. The supported DL/UL resource assignment configurations for TDD can be applied.*
* *For TDD operation, it supports variable DL/UL resource assignment ranging in a radio frame from 10/0 (ten downlink slots and no uplink slot) to 0/10 (no downlink slot and ten uplink slots). It also supports a slot with DL part and UL part. DL and UL transmission directions for data can be dynamically assigned on a per-slot basis. Adjacent cells using the same carrier frequency can use the same or different DL/UL resource assignment configuration.*
* *For both the base station and the terminal, duplexer is not needed.*
* *The TDD guard time is configurable to meet different deployment scenarios.*

***For LTE component RIT:****LTE supports paired and unpaired spectrum and allows FDD operation on a paired spectrum and TDD operation on an unpaired spectrum.** *For FDD operation, it supports both half-duplex and full-duplex FDD.*
	+ *For the base station, a duplexer is needed for half-duplex/full-duplex FDD. For the terminal, a duplexer is needed for full-duplex FDD only.*
	+ *For full-duplex FDD, the required transmit/receive isolation is a UE function of; the Tx emission mask (emission level on the Rx frequency) , the TX-Rx frequency spacing , the Tx- Rx duplex filter isolation, the TX and RX configuration (RB location, RB power and RB allocation) and the required Rx desense criteria. For the supported RIT operating bands, the following parameters are defined in [36.101]:*
* *the minimum (up/down) Tx to Rx frequency separation is 10 MHz*
* *the minimum Tx-Rx band gap is 10 MHz*
	+ *For half-duplex FDD, for the UE there is no specified transmit / receive isolation due half duplex mode.*
* *For TDD operation, it supports variable DL/UL ratio ranging from 9/1 (nine downlink subframes and one uplink subframe) to 4/6 (four downlink subframes and six uplink subframes\*). Adjacent cells using the same carrier frequency can use the same or different DL/UL configuration.*

*\* This is based on an assumption that the “special subframe (see [36.211] sub-clause 4.2) is counted as a DL subframe.** *For both the base station and the terminal, duplexer is not needed.*
* *The TDD guard time is configurable in the range from one to ten OFDM symbols (approximately 70 to 700 µs) to meet different deployment scenarios.*

*For NB-IoT, Half-duplex FDD and TDD are supported. The terminal does not need a duplexer, and there is no specified transmit / receive isolation due to half-duplex mode.* |
| **5.2.3.2.9** | **Support of Advanced antenna capabilities** |
| 5.2.3.2.9.1 | Fully describe the multi-antenna systems (e.g. massive MIMO) supported in the UE, base station, or both that can be used and/or must be used; characterize their impacts on systems performance; e.g., does the RIT have the capability for the use of:– spatial multiplexing techniques,– spatial transmit diversity techniques,– beam-forming techniques (e.g., analog, digital, hybrid). ***For NR component RIT:****The multi-antenna systems in NR supports the following MIMO transmission schemes at both the UE and the base station:** *Spatial multiplexing with DM-RS based closed loop, open loop and semi-open loop transmission schemes are supported. Both codebook and non-codebook based transmission is supported in DL and UL.*
* *Spatial transmit diversity is supported by using specification transparent diversity schemes*
* *Hybrid beamforming including both digital and analog beamforming is supported. Beam management with periodic and aperiodic beam refinement is also supported.*

***For LTE component RIT****The multi-antenna systems in LTE supports the following MIMO transmission scheme at both the UE and the base station:** *Spatial multiplexing with CRS and UE specific RS based closed loop, open loop and semi-open loop transmission schemes are supported. Both codebook and non-codebook based transmission is supported in DL. Codebook based transmission is supported in UL.*
* *Spatial transmit diversity is supported based on space frequency block coding, frequency switched transmit diversity. Specification transparent diversity schemes are also supported*
* *Hybrid beamforming including both digital and analog beamforming is supported.*
 |
| 5.2.3.2.9.2 | How many antenna elements are supported by the base station and UE for transmission and reception? What is the antenna spacing (in wavelengths)? ***For NR component RIT:****NR supports {1, 2, 4, 8, 12, 16, 24, 32} antenna ports in the DL and {1, 2, 4} antenna ports in the UL.**Base Station and UE support rectangular antenna arrays. The rectangular panel array antenna can be described by the following tuple* $(M\_{g},N\_{g}, M,N, P)$*, where* $M\_{g}$ *is the number of panels in a column,* $N\_{g}$ *is the number of panels in row,* $M,N$ *are the number of vertical, horizontal antenna elements within a panel and* $P$ *is number of polarizations per antenna element. The spacing in vertical and horizontal dimensions between the panels is specified by* $d\_{g,V}, d\_{g,H}$ *and between antenna elements by*$ d\_{V}, d\_{H}$*.**NR specification is flexible to support various antenna spacing, number of antenna elements, antenna port layouts and antenna virtualization approaches.****For LTE component RIT****LTE supports {1, 2, 4, 8, 12, 16, 20, 24, 28, 32} antenna ports in the DL and {1, 2, 4} antenna ports in the UL. Base Station and UE support rectangular antenna arrays described by the tuple*$ (M,N,P)$*.* $M, N$ *are the number of antenna elements in the vertical and horizontal dimensions.* $P$ *is the number of polarizations per antenna element. Antenna elements are uniformly spaced in the horizontal direction with a spacing of dH and in the vertical direction with a spacing of dV.**LTE supports various antenna spacing, antenna port layouts and antenna virtualization approaches.* |
| 5.2.3.2.9.3 | Provide details on the antenna configuration that is used in the self-evaluation.*The information will be provided with self evaluation results.* |
| 5.2.3.2.9.4 | If spatial multiplexing (MIMO) is supported, does the proposal support (provide details if supported)– Single-codeword (SCW) and/or multi-codeword (MCW)– Open and/or closed loop MIMO– Cooperative MIMO– Single-user MIMO and/or multi-user MIMO.***For NR component RIT:****In NR, spatial multiplexing is supported with the following options:**Single codeword is supported for 1-4 layer transmissions and two codewords are supported for 5-8 layer transmissions in DL. Only single codeword is supported for 1- 4 layer transmissions in UL**Both open and closed loop MIMO are supported in NR, where for demodulation of data, receiver does not require knowledge of the precoding matrix used at the transmitter. Dynamic switching between different transmission schemes is also supported**Both single-user and multi-user MIMO are supported. For the case of single-user MIMO transmissions, up to 8 orthogonal DM-RS ports are supported in DL and up to 4 orthogonal DM-RS ports are supported in UL. For multi-user MIMO up to 12 orthogonal DM-RS ports with up to 4 orthogonal ports per UE are supported.**NR supports coordinated multipoint transmission/reception, which could be used to implement different forms of cooperative multi-antenna (MIMO) transmission schemes.****For LTE component RIT:****In LTE, spatial multiplexing is supported with the following options:**Single codeword is supported single layer transmissions and two codewords are supported for 2-8 layer transmissions in DL. Single codeword is supported for single layer transmissions and two codewords are supported for 2-4 layer transmissions in UL.**Both open and closed loop MIMO are supported in LTE**LTE supports single user MIMO with up to 8 layers per UE in DL and up to 4 layers per UE in UL. LTE supports MU-MIMO for up to 4 spatial layers in DL, up to 8 spatial layer for UL and up to 2 layers per UE.**LTE supports coordinated multipoint transmission/reception, which could be used to implement different forms of cooperative multi-antenna (MIMO) transmission schemes.* |
| 5.2.3.2.9.5 | Other antenna technologies Does the RIT/SRIT support other antenna technologies, for example:– remote antennas,– distributed antennas.If so, please describe.*The use of remote antennas and distributed antennas is supported by NR and LTE.* |
| 5.2.3.2.9.6 | Provide the antenna tilt angle used in the self-evaluation.*The information will be provided with self evaluation results.* |
| **5.2.3.2.10** | **Link adaptation and power control** |
| 5.2.3.2.10.1 | Describe link adaptation techniques employed by RIT/SRIT, including:– the supported modulation and coding schemes,– the supporting channel quality measurements, the reporting of these measurements, their frequency and granularity.Provide details of any adaptive modulation and coding schemes, including:– Hybrid ARQ or other retransmission mechanisms? – Algorithms for adaptive modulation and coding, which are used in the self-evaluation. – Other schemes?***For NR component RIT:****For data, the RIT supports dynamic indication of* 1. *combinations of modulation scheme and target code rate and,*
2. *the resource allocation in frequency and time (The resource allocation in frequency is within BWP)*

*that the UE uses to determine the transport block size where the possible combinations cover a large range of possible data and channel coding rates. 28 different target coding rates can be indicated (29 if 256QAM is not enabled) and the target code rate range is 0.1 to 0.9.* *In both downlink and uplink, link adaptation (selection of modulation scheme and code rate) is controlled by the base station. In the downlink, the network selection of modulation-scheme/code-rate combination can e.g. be based on channel state information (CSI) reported by the terminals. The RIT features a flexible CSI framework where the type of CSI, reporting quantity, frequency-granularity and time-domain behaviour can be configured. Both periodic and aperiodic(triggered) reporting modes are supported, controlled by the base station, where the aperiodic reporting allows the network to request which CSI-RS resources to report the CSI for. More details can be found in [38.214] section 5.2. In the uplink the base station may measure either the traffic channel or sounding reference signals and use this as input to the link adaptation. More details can be found in [38.214] section 6.2.1.**On the MAC layer, hybrid ARQ with soft-combining between transmissions is supported. Different redundancy versions can be used for different transmissions. The modulation and coding scheme may be changed for retransmissions. In order to minimize delay and feedback, a set of parallel stop-and-wait protocols are used. To correct possible residual errors, the MAC ARQ is complemented by a robust selective-repeat ARQ protocol on the RLC layer. More details are found in [38.321] and [38.322].****For LTE component RIT:****For data, the RIT supports the modulation schemes QPSK, 16 QAM, 64 QAM, 256QAM and 1024QAM, and code rates between approximately 0.1 and 0.9. Some 27**different modulation-scheme/code-rate combinations exist. This is valid for both downlink and uplink.* *In both downlink and uplink, link adaptation (selection of modulation scheme and code rate) is controlled by the base station. In the downlink the network selection of modulation-scheme/code-rate combination can e.g. be based on Channel Quality Indicators (CQIs) reported by the terminals. Several different CQI modes exist, including frequency-selective and wideband modes, periodic and aperiodic modes. The CQI mode is controlled by the base station. In the uplink the base station may measure either the traffic channel or sounding reference signals and use this as input to link adaptation. More details are found in [36.213]. UE reports its headroom to its maximum power to assist the base station with uplink link adaptation.**On the MAC layer, hybrid ARQ with soft-combining between transmissions is supported. Different redundancy versions can be used for different transmissions. The modulation scheme may be changed for retransmissions. In order to minimize delay and feedback, a set of parallel stop-and-wait protocols are used. To correct possible residual errors, the MAC HARQ is complemented by a robust selective-repeat ARQ protocol on the RLC layer. More details are found in [36.321] and [36.322].**For NB-IoT BPSK and QPSK modulation schemes are supported. Transmissions of a transport block can be mapped to between 1 and 10 subframes to adapt the code rate of the transmission. In its most basic form the link adaptation supports 116 alternative modulation-scheme/code-rate combinations for the UL and 104 alternatives for the DL. To further enhance the link robustness NB-IoT supports repetition based transmission scheme using up to 2048 repetitions of each modulation-scheme/code-rate combination.**During the connection setup procedure NB-IoT supports a basic UE feedback mechanism which allows the base station to access the coupling loss experienced by a UE. In connected mode HARQ and ARQ RLC/MAC feedback is supported in similarity to LTE.*  |
| 5.2.3.2.10.2 | Provide details of any power control scheme included in the proposal, for example:– Power control step size (dB)– Power control cycles per second– Power control dynamic range (dB)– Minimum transmit power level with power control– Associated signalling and control messages.***For NR component RIT:****Uplink power control is independent for uplink data(PUSCH), uplink control(PUCCH) and sounding reference signal SRS. The uplink power control is based on both signal-strength measurements done by the terminal itself (open-loop power control), as well as measurements by the base station. The latter measurements are used to generate power-control commands that are subsequently fed back to the terminals as part of the downlink control signaling (closed-loop power control). Both absolute and relative power-control commands are supported. There are four available relative power adjustments (“step size”) in case of relative power control, TBD. For uplink data, multiple closed loop power control processes can be configured, including the possibility separate processes with transmission beam indication. The time between power-control commands for PUSCH and PUCCH is the same as the scheduling periodicity for the PUSCH and the PDSCH, respectively. More details about uplink power control are found in [38.213] section 7.**Downlink power control is network-implementation specific and thus outside the scope of the specification. A simple and efficient power control strategy is to transmit with a constant output power. Variations in channel conditions and interference levels are adapted to by means of scheduling and link adaptation.****For LTE component RIT:****The RIT uplink power control is based on both signal-strength measurements done by the terminal itself (open-loop power control), as well as measurements by the base station. The later measurements are used to generate power-control commands that are subsequently fed back to the terminals as part of the downlink control signaling (closed-loop power control). Both absolute and relative power-control commands are supported. The available relative power adjustments (“step size”) in case of relative power control are [-1 dB, 0 dB, +1 dB, +3 dB]. The time between power-control commands can be down to 1ms, but even down to roughly 140 µs for sTTI. The minimum transmit power requirement, – 40dBm, yields a dynamic range of -40 to 23=63dB for a terminal with maximum power 23dBm. Higher power terminals with 26 dBm and 31 dBm maximum power are also supported increasing the dynamic range accordingly. For eMTC and NB-IoT maximum UE power supported are 14 dBm, 20 dBm and 23 dBm. NB-IoT only supports the open-loop power control, with a constraint that full power is used when the UE is commanded to use 2 or more repetitions of a physical channel. More details about uplink power control are found in [36.213].**Downlink power control is, with the exception for NB-IoT, network-implementation specific and thus outside the scope of the specification. A simple and efficient power control strategy is to transmit with a constant output power. Variations in channel conditions and interference levels are adapted to by means of scheduling and link adaptation rather than with power control. For NB-IoT the network is mandated to support at least 6 dB power boosting of the PRB carrying the synchronization and broadcast signaling. The configured power boosting value is signaled by the base station to the terminals.* |
| **5.2.3.2.11** | **Power classes** |
| 5.2.3.2.11.1  | *UE emitted power* |
| 5.2.3.2.11.1.1 | What is the radiated antenna power measured at the antenna (dBm)?*The information will be provided in later update.* |
| 5.2.3.2.11.1.2  | What is the maximum peak power transmitted while in active or busy state?*The information will be provided in later update.* |
| 5.2.3.2.11.1.3 | What is the time averaged power transmitted while in active or busy state? Provide a detailed explanation used to calculate this time average power.*The information will be provided in later update.* |
| 5.2.3.2.11.2 | *Base station emitted power* |
| 5.2.3.2.11.2.1 | What is the base station transmit power per RF carrier?*The information will be provided in later update.* |
| 5.2.3.2.11.2.2  | What is the maximum peak transmitted power per RF carrier radiated from antenna?*The information will be provided in later update.* |
| 5.2.3.2.11.2.3 | What is the average transmitted power per RF carrier radiated from antenna?*The information will be provided in later update.* |
| **5.2.3.2.12** | **Scheduler, QoS support and management, data services** |
| 5.2.3.2.12.1 | QoS support– What QoS classes are supported?– How QoS classes associated with each service flow can be negotiated.– QoS attributes, for example: • data rate (ranging from the lowest supported data rate to maximum data rate supported by the MAC/PHY); • control plane and user plane latency (delivery delay); • packet error ratio (after all corrections provided by the MAC/PHY layers), and delay variation (jitter).– Is QoS supported when handing off between radio access networks? If so, describe the corresponding procedures.– How users may utilize several applications with differing QoS requirements at the same time.*The information will be provided in later update.* |
| 5.2.3.2.12.2 | *Scheduling mechanisms*– Exemplify scheduling algorithm(s) that may be used for full buffer and non-full buffer traffic in the technology proposal for evaluation purposes.Describe any measurements and/or reporting required for scheduling. *The information will be provided in later update.* |
| **5.2.3.2.13** | **Radio interface architecture and protocol stack** |
| 5.2.3.2.13.1 | Describe details of the radio interface architecture and protocol stack such as:– Logical channels– Control channels– Traffic channelsTransport channels and/or physical channels.***SRIT RAN/Radio Architectures:****This SRIT contains NR and LTE “standalone” architectures. Besides NR and LTE “standalone” architectures and operation, certain NR-LTE interworking options are defined, using “multi-RAT dual connectivity” (MR-DC) operation, e.g. (ref. to [37.340]):* * ***E-UTRA-NR Dual Connectivity (EN-DC),*** *in which a UE is connected to one eNB (MN) and one en-gNB (SN). The eNB is connected to the EPC and the en-gNB is connected to the eNB via the X2 interface.*
* ***NG-RAN E-UTRA-NR Dual Connectivity (NGEN-DC),*** *similar architecture to EN-DC, but the eNB is connected to 5GC.*
* ***NR-E-UTRA Dual Connectivity (NE-DC),*** *in which a UE is connected to one gNB (MN) and one ng-eNB (SN). The gNB is connected to 5GC and the ng-eNB is connected to the gNB via the Xn interface.*

***High-level summary of radio interface protocols:****The following paragraphs provide a high level summary of radio interface protocols and channels, with focus on NR standalone and LTE/E-UTRA standalone (covering also some specific aspects of eMTC/NB-IOT, as well as EN-DC).* ***For NR component RIT:****Radio Protocols:**The protocol stack for the user plane includes the following: SDAP, PDCP, RLC, MAC, and PHY sublayers (terminated in UE and gNB).**On the Control plane, the following protocols are defined:*- *RRC, PDCP, RLC, MAC and PHY sublayers (terminated in UE and gNB);**- NAS protocol (terminated in UE and AMF)**For details on protocol services and functions, please refer to 3GPP specifications (e.g. [38.300]).**Radio Channels (Physical, Transport and Logical Channels)**The physical layer offers service to the MAC sublayer transport channels. The MAC sublayer offers service to the RLC sublayer logical channels. The RLC sublayer offers service to the PDCP sublayer RLC channels. The PDCP sublayer offers service to the SDAP and RRC sublayer radio bearers: data radio bearers (DRB) for user plane data and signalling radio bearers (SRB) for control plane data.**The SDAP sublayer offers 5GC QoS flows and DRBs mapping function.**The physical channels defined in the downlink are:* *- the Physical Downlink Shared Channel (PDSCH),* *- the Physical Downlink Control Channel (PDCCH),* *- the Physical Broadcast Channel (PBCH),* *The physical channels defined in the uplink are:* *- the Physical Random Access Channel (PRACH),**- the Physical Uplink Shared Channel (PUSCH),* *- and the Physical Uplink Control Channel (PUCCH).* *In addition to the physical channels above, PHY layer signals are defined, which an be reference signals, primary and secondary synchronization signals.**The following transport channels, and their mapping to PHY channels, are defined:**Uplink:** *Uplink Shared Channel (UL-SCH), mapped to PUSCH*
* *Random Access Channel (RACH), mapped to PRACH*

*Downlink:** *Downlink Shared Channel (DL-SCH), mapped to PDSCH*
* *Broadcast channel (BCH), mapped to PBCH*
* *Paging channel (PCH), mapped to (TBD)*

*Logical channels are classified into two groups: Control Channels and Traffic Channels. Control channels:** *Broadcast Control Channel (BCCH): a downlink channel for broadcasting system control information.*
* *Paging Control Channel (PCCH): a downlink channel that transfers paging information and system information change notifications.*
* *Common Control Channel (CCCH): channel for transmitting control information between UEs and network.*
* *Dedicated Control Channel (DCCH): a point-to-point bi-directional channel that transmits dedicated control information between a UE and the network.*

*Traffic channels:**Dedicated Traffic Channel (DTCH), which can exist in both UL and DL.**In Downlink, the following connections between logical channels and transport channels exist:** *BCCH can be mapped to BCH, or DL-SCH;*
* *PCCH can be mapped to PCH;*
* *CCCH, DCCH, DTCH can be mapped to DL-SCH;*

*In Uplink, the following connections between logical channels and transport channels exist:**- CCCH,DCCH, DTCH can be mapped to UL-SCH.**Other aspects**- NR QoS architecture**The QoS architecture in NG-RAN (connected to 5GC), can be summarized as follows:**For each UE, 5GC establishes one or more PDU Sessions.**For each UE, the NG-RAN establishes one or more Data Radio Bearers (DRB) per PDU Session. The NG-RAN maps packets belonging to different PDU sessions to different DRBs. Hence, the NG-RAN establishes at least one default DRB for each PDU Session.**NAS level packet filters in the UE and in the 5GC associate UL and DL packets with QoS Flows.**AS-level mapping rules in the UE and in the NG-RAN associate UL and DL QoS Flows with DRBs**-* *Carrier Aggregation (CA)**In case of CA, the multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per serving cell.**- Dual Connectivity (DC)**In DC, the radio protocol architecture that a radio bearer uses depends on how the radio bearer is setup. Four bearer types exist: MCG bearer, MCG split bearer, SCG bearer and SCG split bearer. The following terminology/definitions apply:** *Master gNB: in dual connectivity, the gNB which terminates at least NG-C.*
* *Secondary gNB: in dual connectivity, the gNB that is providing additional radio resources for the UE but is not the Master node.*
* *Master Cell Group (MCG): in dual connectivity, a group of serving cells associated with the MgNB*
* *Secondary Cell Group (SCG): in dual connectivity, a group of serving cells associated with the SgNB*
* *MCG bearer: in dual connectivity, a bearer whose radio protocols are only located in the MCG.*
* *MCG split bearer: in dual connectivity, a bearer whose radio protocols are split at the MgNB and belong to both MCG and SCG.*
* *SCG bearer: in dual connectivity, a bearer whose radio protocols are only located in the SCG.*
* *SCG split bearer: in dual connectivity, a bearer whose radio protocols are split at the SgNB and belong to both SCG and MCG.*

*In case of DC, the UE is configured with two MAC entities: one MAC entity for the MCG and one MAC entity for the SCG. For a split bearer, UE is configured over which link (or both) the UE transmits UL PDCP PDUs. On the link which is not responsible for UL PDCP PDUs transmission, the RLC layer only transmits corresponding ARQ feedback for the downlink data.**For more details on NR Radio Protocol architecture and channels, refer to:**[38.300], [38.401], [38.201], [37.340]****For LTE component RIT:****NOTE: eMTC/NB-IoT uses optimized physical layer and radio procedures (e.g. for very low power consumption), thus a number of E-UTRA protocol mechanisms and functions are either not used, or are specific to eMTC/NB-IOT only. Some examples of functionalities not needed for NB-IOT are: inter-RAT mobility, handover, measurement reports, carrier aggregation, dual connectivity, and others. Only few exceptions/variations are highlighted below; for details please refer to stage-3 specifications.**Radio Protocol stack**The protocol stack for the user plane includes PDCP, RLC, MAC, and PHY sublayers (terminated in UE and eNB).For NB-IoT, the user plane is not used when transferring data over NAS.**On the Control plane, the following protocols are defined:*- *RRC, PDCP, RLC, MAC and PHY sublayers (terminated in UE and eNB);**- NAS protocol (terminated in UE and Core Network)**For NB-IoT, if certain optimizations are supported, PDCP can be bypassed (at all, or until AS security is activated)**For details on protocol services and functions, please refer to 3GPP specifications (e.g. TS 36.300).**Radio Channels (Physical, Transport and Logical Channels)**The main E-UTRA physical channels, and mapped transport channels, are:**DL:** *Physical broadcast channel (PBCH)*
	+ *Carries the BCH transport channel*
* *Physical downlink shared channel (PDSCH)*
	+ *Carries the DL-SCH and PCH transport channels*
* *Physical control format indicator channel (PCFICH)*
* *Physical downlink control channel (PDCCH)*
* *Enhanced physical downlink control channel (EPDCCH)*
* *Physical Hybrid ARQ Indicator Channel (PHICH)*

*UL:** *Physical uplink control channel (PUCCH)*
* *Physical uplink shared channel (PUSCH)*
	+ *Carries the UL-SCH transport channel*
* *Physical random access channel (PRACH)*
	+ *Carries the RACH transport channel*

*eMTC specific physical channels:** *MTC physical downlink control channel (MPDCCH)*

*NB-IOT specific physical channels:** *Narrowband Physical broadcast channel (NPBCH)*
* *Narrowband Physical downlink shared channel (NPDSCH)*
* *Narrowband Physical downlink control channel (NPDCCH)*
* *Narrowband Physical uplink shared channel (NPUSCH)*
* *Narrowband Physical random access channel (NPRACH)*

*In addition to the above channels, two types of physical signals are defined: reference or synchronization signals.**E-UTRA Logical channels (at MAC/RLC sublayer) are:**- Control Channels (for the transfer of control plane information), e.g.:**- Broadcast Control Channel (BCCH)**- For NB-IOT, Bandwidth Reduced Broadcast Control Channel (BR-BCCH)**- Paging Control Channel (PCCH)**- Common Control Channel (CCCH)**- Dedicated Control Channel (DCCH)**- Traffic Channels (for the transfer of user plane information), e.g..**- Dedicated Traffic Channel (DTCH)**The following mapping between logical channels and transport channels is defined:**In Uplink, CCCH, DCCH and DTCH can be mapped to UL-SCH;In Downlink,**- BCCH can be mapped to BCH, or DL-SCH;**- BR-BCCH can be mapped to DL-SCH;**- PCCH can be mapped to PCH;**- CCCH, DCCH and DTCH can be mapped to DL-SCH* *Other Aspects**- Carrier Aggregation (CA)**In Carrier Aggregation (CA), two or more Component Carriers (CCs) are aggregated in order to support wider transmission bandwidths. A UE may simultaneously receive or transmit on one or multiple CCs depending on its capabilities.* *The multi-carrier nature of the physical layer is only exposed to the MAC layer for which one HARQ entity is required per serving cell.**- In both uplink and downlink, there is one independent hybrid-ARQ entity per serving cell and one transport block is generated per TTI per serving cell (in the absence of spatial multiplexing). Each transport block and its potential HARQ retransmissions are mapped to a single serving cell;**- Dual Connectivity (DC)**In DC, the configured set of serving cells for a UE consists of two subsets: the Master Cell Group (MCG) containing the serving cells of the MeNB, and the Secondary Cell Group (SCG) containing the serving cells of the SeNB**The DC UE is configured with two MAC entities: one MAC entity for MeNB and one MAC entity for SeNB.**- E-UTRA-NR Dual Connectivity (EN-DC)**E-UTRAN supports also Multi-RAT Dual Connectivity (MR-DC) with NR, e.g. one MR-DC architecture is E-UTRA-NR Dual Connectivity (EN-DC), in which a UE is connected to one eNB that acts as a MN and one en-gNB that acts as a SN. The eNB is connected to the EPC and the en-gNB is connected to the eNB via the X2 interface.**- NB-IOT For NB-IoT, CA and DC are not supported; only a specific multi-carrier operation is defined (e.g. a RRC\_CONNECTED UE can be configured to a non-anchor carrier, for all unicast transmissions).* *For more details on LTE Radio Protocol architecture and channels, refer to:**[36.300], [36.401], [36.201], [37.340]* |
| 5.2.3.2.13.2 | What is the bit rate required for transmitting feedback information?*The information will be provided in later update.* |
| 5.2.3.2.13.3 | *Channel access:*Describe in details how RIT/SRIT accomplishes initial channel access, (e.g. contention or non-contention based).***For NR and LTE component RIT (****Common principles)**Initial channel access is typically accomplished via the “random access procedure” (assuming no dedicated/scheduled resources are allocated).* *The random access procedure can be contention based (e.g. at initial connection from idle mode) or non-contention based (e.g. during Handover to a new cell). Random access resources and parameters are configured by the network and signalled to the UE (via broadcast or dedicated signaling).**Contention based random access procedure encompasses the transmission of a random access preamble by the UE (subject to possible contention with other UEs), followed by a random access response (RAR) in DL (including allocating specific radio resources for the uplink transmission). Afterwards, the UE transmits the initial UL message (e.g. RRC connection Request) using the allocated resources, and wait for a contention resolution message in DL (to confirming access to that UE). The UE could perform multiple attempts until it is successful in accessing the channel or until a timer (supervising the procedure) elapses.* *Non-contention based random access procedure foresees the assignment of a dedicated random access resource/preamble to a UE (e.g. part of an HO command). This avoids the contention resolution phase, i.e. only the random access preamble and random access response messages are needed to get channel access.**From a L1 perspective, a random access preamble is transmitted (UL) in a PRACH, random access response (DL) in a PDSCH, UL transmission in a PUSCH, and contention resolution message (DL) in a PDSCH.**Other/specific RIT aspects**Detailed aspects and mechanisms of the random access procedure are specific/different for each RIT (NR and LTE), e.g. physical resources/channels, timing, messages/parameters, etc.**For eMTC/NB-IOT, there are also specific differences, e.g.* *- For eMTC: PRACH configuration/repetition, decoding/interpretation of Random Access Response (RAR), etc.**- For NB-IOT: dedicated (narrowband) PRACH channel, configuration, RAR decoding, etc.**For more details, refer to:**- NR: [38.300], [38.321] and [38.213]**- LTE: [36.300], [36.321] and [36.213]* |
| **5.2.3.2.14** | **Cell selection** |
| 5.2.3.2.14.1 | Describe in detail how the RIT/SRIT accomplishes cell selection to determine the serving cell for the users.***For NR and LTE component RIT:****Cell selection is based on the following principles, common for NR and LTE:**- The UE NAS layer identifies a selected PLMN (and equivalent PLMNs, if any);**- The UE searches the supported frequency bands (RIT specific) and for each carrier frequency it searches and identifies the strongest cell. It reads cell broadcast information to identify its PLMN(s) and other relevant parameters (e.g. related to cell restrictions);**- The UE seeks to identify a suitable cell; if it is not able to identify a “suitable” cell it seeks to identify an “acceptable” cell.* *- A cell is “suitable” if: the measured cell attributes satisfy the cell selection criteria (based on DL radio signal strength/quality); the cell belongs to the selected/equivalent PLMN; cell is not restricted (e.g. cell is not barred/reserved or part of "forbidden" roaming areas);**- An “acceptable” cell is one for which the measured cell attributes satisfy the cell selection criteria and the cell is not barred.**Among the identified suitable (or acceptable) cells, the UE selects the strongest cell, (technically it “camps” on that cell).**As signalled/configured by the radio network, certain frequencies or RITs could be prioritized for camping.**Other/specific RIT aspects**Detailed aspects and mechanisms of cell selection are specific/different for each RIT (NR and LTE), e.g.:**- frequency/cell search (using different DL sync signals and search procedures)**- broadcast system information acquisition/signalling**- RF measurement and metrics/thresholds for selection criteria* *Few specific mechanisms/restrictions apply to eMTC/NB-IOT, e.g.:**- NB-IOT uses specific DL signals and (optimized/limited) cell search and measurement procedures**- Specific cell selection criteria may apply to eMTC**For more details, refer to:**- NR: [38.300] sub-clause 9.2.1.1 and [38.304] sub-clause 5.2**- LTE: [36.300] sub-clause 10.1.1.1 and [36.304] sub-clause 5.2* |
| **5.2.3.2.15** | **Location determination mechanisms** |
| 5.2.3.2.15.1 | Describe any location determination mechanisms that may be used, e.g., to support location based services. *The information will be provided in later update* |
| **5.2.3.2.16** | **Priority access mechanisms** |
| 5.2.3.2.16.1 | Describe techniques employed to support prioritization of access to radio or network resources for specific services or specific users (e.g., to allow access by emergency services).*The information will be provided in later update* |
| **5.2.3.2.17** | **Unicast, multicast and broadcast** |
| 5.2.3.2.17.1 | Describe how the RIT/SRIT enables:– broadcast capabilities,– multicast capabilities,– unicast capabilities,using both dedicated carriers and/or shared carriers. Please describe how all three capabilities can exist simultaneously.*The information will be provided in later update* |
| 5.2.3.2.17.2 | Describe whether the proposal is capable of providing multiple user services simultaneously to any user with appropriate channel capacity assignments?*The information will be provided in later update* |
| 5.2.3.2.17.3 | Provide details of the codec used.Does the RIT/SRIT support multiple voice and/or video codecs? Provide the detail.*The information will be provided in later update* |
| **5.2.3.2.18** | **Privacy, authorization, encryption, authentication and legal intercept schemes**  |
| 5.2.3.2.18.1 | Any privacy, authorization, encryption, authentication and legal intercept schemes that are enabled in the radio interface technology should be described. Describe whether any synchronisation is needed for privacy and encryptions mechanisms used in the RIT/SRIT.Describe how the RIT/SRIT addresses the radio access security, with a particular focus on the following security items:– system signalling integrity and confidentiality,– user equipment identity authentication and confidentiality,– subscriber identity authentication and confidentiality,– user data integrity and confidentialityDescribe how the RIT/SRIT may be protected against attacks, for example: – passive, – man in the middle,– replay,– denial of service. *The information will be provided in later update* |
| **5.2.3.2.19** | **Frequency planning** |
| 5.2.3.2.19.1 | How does the RIT/SRIT support adding new cells or new RF carriers? Provide details.*The information will be provided in later update* |
| **5.2.3.2.20** | **Interference mitigation within radio interface** |
| 5.2.3.2.20.1 | Does the proposal support Interference mitigation? If so, describe the corresponding mechanism.***For NR component RIT:****The RIT has been designed with the aim to minimize the always-on signals to reduce the interference in the system. This is achieved by:** *Support longer periodicities for synchronization signals, broadcast channels and periodic reference signals*
* *Use UE-specific demodulation reference signals for control and data that are only transmitted when control and/or data is being transmitted*
* *Control channel resource allocation in the frequency domain is configurable to reduce the interference to control channels in neighbouring cells*

*Coordinated multipoint transmission/reception (CoMP) is another approach supported by the RIT to mitigate interference between cells and improve system performance by dynamic coordination in the scheduling/transmission and/or joint transmission between/from multiple cell sites.****For LTE component RIT:****Static inter-cell interference mitigation is supported by means of e.g. frequency reuse, soft frequency reuse, and reuse partitioning.* *Inter-cell interference mitigation is supported by means of exchanging interference measurements and scheduling decisions between base stations, see also 5.2.3.2.20.2 below.**Coordinated multipoint transmission/reception (CoMP) is another approach supported by the RIT to mitigate interference between cells and improve system performance.**Coordinated multipoint transmission implies dynamic coordination in the scheduling/transmission and/or joint transmission between/from multiple cell sites.* *Coordinated multipoint reception implies dynamic coordination in the scheduling and/or joint reception between/at difference cell sites.**The coordinated cell sites could either correspond to cells of the same eNB (intra-eNB coordination) or different eNB (inter-eNB coordination).**For eMTC and NB-IoT a repetition based transmission scheme is supported where coherent reception of repeated transmission supports suppression of interference. Cell and user based scrambling is also implemented to support this mechanism. eMTC supports frequency hopping to reduce the impact from interference.* |
| 5.2.3.2.20.2 | What is the signalling, if any, which can be used for intercell interference mitigation?***For NR component RIT:*** *The information will be provided in later update.****For LTE component RIT:****To aid inter-cell interference mitigation, the RIT defines three indicators exchanged between base stations: The High-interference Indicator (HI) which provides information to neighbouring cells about the part of the cell bandwidth upon which the cell intends to schedule its cell-edge user, the Overload Indicator (OI) which provides information on the uplink interference level experienced in each part of the cell bandwidth and Relative Narrowband TX Power (RNTP) indicator, which provides information on the downlink transmission power.* |
| 5.2.3.2.20.3 | *Link level interference mitigation*Describe the feature or features used to mitigate intersymbol interference.***For NR component RIT:****The use of a cyclic prefix OFDM transmission in both UL(with or without transform precoding) and DL, provides robustness against intersymbol interference.****For LTE component RIT:****The use of a cyclic prefix OFDM transmission in both UL (with or without transform precoding) and DL, provides robustness against intersymbol interference.**See also answer to 5.2.3.2.20.4* |
| 5.2.3.2.20.4 | Describe the approach taken to cope with multipath propagation effects (e.g. via equalizer, rake receiver, cyclic prefix, etc.). ***For NR component RIT:****The use of OFDM transmission in both UL and DL, in combination with a cyclic prefix, provides inherent robustness to time-dispersion/frequency-selectivity on the radio channel.* *In case of transform precoding in the UL, time-dispersion/frequency-selectivity on the radio channel can be handled by receiver-side equalization.****For LTE component RIT:****On the downlink, the use of OFDM transmission, in combination with a cyclic prefix, provides inherent robustness to time-dispersion/frequency-selectivity on the radio channel.**On the uplink, time-dispersion/frequency-selectivity on the radio channel can be handled by receiver-side equalization. The detailed equalization approach is implementation dependent. Examples of equalization approaches include frequency-domain linear equalization and Turbo equalization. The use of cyclic prefix also for the uplink may simplify the equalizer implementation.* |
| 5.2.3.2.20.5 | *Diversity techniques*Describe the diversity techniques supported in the user equipment and at the base station, including micro diversity and macro diversity, characterizing the type of diversity used, for example:– Time diversity: repetition, Rake-receiver, etc.– Space diversity: multiple sectors, etc.– Frequency diversity: frequency hopping (FH), wideband transmission, etc.– Code diversity: multiple PN codes, multiple FH code, etc.– Multi-user diversity: proportional fairness (PF), etc.– Other schemes.Characterize the diversity combining algorithm, for example, switched diversity, maximal ratio combining, equal gain combining. Provide information on the receiver/transmitter RF configurations, for example:– number of RF receivers– number of RF transmitters.***For NR component RIT:****The RIT provides the following means for diversity:* * *Space diversity by means of multiple transmit and receiver antennas and beamforming*
	+ *Number of TX-antenna ports: This is a deployment choice, but for the purpose of multi-layer transmissions up to 12 downlink and up to 4 uplink antenna ports have been defined where the mapping of ports to physical antennas is an implementation issue*
	+ *Number of RX antenna ports: Implementation specific*
* *Frequency diversity by means of wide overall transmission bandwidth and possibility for uplink frequency hopping and uplink and downlink frequency-distributed transmissions*
* *Time diversity by means of fast retransmissions with hybrid ARQ protocol allowing combining of the retransmissions with the original transmission*
* *Multi-user diversity by means of channel-aware scheduling*

***For LTE component RIT:****The RIT provides the following means for diversity:* * *Space diversity by means of multiple transmit and receiver antennas*
	+ *Number of TX antenna ports: Up to 8 (DL), up to 4 (UL) logical antenna ports are defined where the mapping of logical antenna ports to physical antennas is an implementation specific configuration.*
	+ *Number of RX antenna ports: Implementation specific*
* *Frequency diversity by means of wide overall transmission bandwidth. Possibility for uplink frequency hopping on a slot basis and downlink frequency-distributed transmission*
* *Time diversity by means of fast retransmissions*
* *Multi-user diversity by means of channel-aware scheduling*

*For NB-IoT transmission 2 DL and 1 UL logical antenna ports are defined. For eMTC, frequency and time diversity is supported by frequency hopping on the random access channel and time based repetitions on all physical channels. For eMTC, frequency hopping is supported.* |
| **5.2.3.2.21** | **Synchronization requirements** |
| 5.2.3.2.21.1 | Describe RIT’s/SRIT’s timing requirements, e.g.– Is base station-to-base station synchronization required? Provide precise information, the type of synchronization, i.e., synchronization of carrier frequency, bit clock, spreading code or frame, and their accuracy.– Is base station-to-network synchronization required?State short-term frequency and timing accuracy of base station transmit signal.***For NR and LTE component RIT:****Common general aspects**Tight BS-to-BS synchronization is not required. Likewise, tight BS-to-network synchronization is not required.**The BS shall support a logical synchronization port for phase-, time- and/or frequency synchronization, e.g. to provide.** *accurate maximum relative phase difference for all BSs in synchronized TDD area*
* *continuous time without leap seconds traceable to common time reference for all BSs in synchronized TDD area;*
* *FDD time domain inter-cell interference coordination.*

*Furthermore, common SFN initialization time shall be provided for all BSs in synchronized TDD area.**A certain RAN-CN Hyper SFN synchronization is required in case of extended Idle mode DRX.**Some accuracy requirements**BS transmit signals accuracy:* * *LTE: Frequency and timing accuracy of BS transmit signal is within ±0.05 ppm observed over a period of one subframe (1 ms).*
* *NR: The information will be provided in later update.*

*Cell phase synchronization accuracy:** *NR: The cell phase synchronization accuracy measured at BS antenna connectors shall be better than [3] µs.*
* *LTE: for Wide Area BS (not considering Home BS), the cell phase synchronization accuracy measured at BS antenna connectors shall be better than 3 µs for small cells (radius up to 3km), 10 µs for large cells (radius above 3km).*

*For more information please refer to* * *NR: [38.401], [38.133].*
* *LTE: [36.401], [36.133].*
 |
| 5.2.3.2.21.2 | Describe the synchronization mechanisms used in the proposal, including synchronization between a user terminal and a base station. ***For NR and LTE component RIT*** *(common principles)**Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. A UE receives the following synchronization signals (SS) in order to perform cell search: the primary synchronization signal (PSS) and secondary synchronization signal (SSS). PSS is used (at least) for initial symbol boundary, cyclic prefix, sub frame boundary, initial frequency synchronization to the cell. SSS is used for radio frame boundary identification. PSS and SSS together used for cell ID detection.* *Other synchronization mechanisms are defined e.g. for Radio link monitoring, Transmission timing adjustments, Timing for cell activation / deactivation.**- For NB-IOT**NB-IoT cell search/synchronization is based on dedicated narrowband signals transmitted in the downlink: the primary and secondary narrowband synchronization signals.**See more information in:** *NR: [38.213] sub-clause 4 and [38.211] sub-clause 7.4.2.*
* *LTE: [36.213] and [36.211].*
 |
| 5.2.3.2.22 | Link budget templateProponents should complete the link budget template in § 45.2.3.3 to this description template for the environments supported in the RIT.*The information will be provided with link budget template in later update.* |
| **5.2.3.2.23** | **Support for wide range of services** |
| 5.2.3.2.23.1 | Describe what kind of services/applications can be supported in each usage scenarios in Recommendation ITU-R M.2083 (eMBB, URLLC, and mMTC).*This proposal supports a wide range of services across the diverse usage scenarios including eMBB, URLLC, and mMTC envisaged in Recommendation ITU-R M.2083.**The example services supported by this proposal include the services defined in* *Recommendation ITU-R M.1822, [22.261], and other services, such as** *eMBB services including conversational services (including basic/ rich conversational services, low delay conversational services), interactive (with high and low delay) services, streaming (live/non-live) services, and other high data rate services; for stationary users, pedestrian users, to high speed train/vehicle users.*
* *URLLC services including transportation safety, smart grid, mobile health application, wireless industry automation, etc.*
* *mMTC services including smart city, smart home applications, and other machine-type communication (also known as Machine-to-Machine (M2M)) services.*
 |
| 5.2.3.2.23.2 | Describe any capabilities/features to flexibly deploy a range of services across different usage scenarios (eMBB, URLLC, and mMTC) in an efficient manner, (e.g., a proposed RIT/SRIT is designed to use a single continuous or multiple block(s) of spectrum).***For NR component RIT:****NR is capable of deploying a range of services across different usage scenarios. While the specification does not match any physical layer functionality to any service, different components can benefit different services in specific usage scenarios.* *Specifically, the following low latency structures cater especially to the URLLC services*-     *Front loaded DMRS allows for the channel estimate to be ready before the full data block is received*-     *Frequency-first mapping of data bits to physical resources allows for the channel decoder to operate in a pipelined fashion, starting to decode the data block immediately when the first symbol has been received*-     *Very tight UE processing time budget especially targeted for ultra-low latency device types*-     *Very short scheduling interval achieved with both high subcarrier spacing (short symbol duration) and the possibility to schedule short time intervals only**- At least an UL transmission scheme without scheduling grant is supported to reduce UL latency.**mMTC services can benefit from the following components*-     *DFT-spreading and Pi/2 BPSK modulation for reduced PAPR and increased average Tx power for better coverage*-     *Slot aggregation for both control and data for better coverage* -     *High-aggregation level downlink control for better coverage*-     *RRC inactive state for optimized signalling overhead when moving to active state*-     *Extended DRX cycle for RRC active state to improve battery life*-     *Support for narrow-band (low-cost) UEs within a wide-band carrier**URLLC, eMBB and mMTC services can coexist within the same spectrum in both time and frequency domain in multiplexed manner. URLLC can pre-empt ongoing eMBB/mMTC transmissions, if necessary, and URLLC services can be mapped to e.g. a shorter allocation duration for lower latency by small number of scheduled symbols, as well as by using higher sub-carrier spacing and thus allocation duration for the same number of scheduled symbols, while eMBB services can be mapped to do the opposite. Different sub-carrier spacings and scheduling interval durations that are appropriate to the desired service type (e.g., different latency and data rate requirements) can coexist in a single carrier with no need for fixed divisions within the carrier, by e.g., using spectral refinement techniques such as filtering, windowing, etc. with the designated waveforms for NR.****For LTE component RIT:****LTE is capable of deploying a range of services across different usage scenarios. While the specification does not match any physical layer functionality to any service, different components can benefit different services in specific usage scenarios.* *Specifically, the following low latency components are enabled** *Frequency-first mapping of data bits to physical resources allows for the channel decoder to operate in a pipelined fashion, starting to decode the data block immediately when the first symbol has been received*
* *Short scheduling interval achieved with short TTI length (see item 5.2.3.2.7 and reference therein)*
* *Configurable shorter uplink semi-persistent-scheduling (SPS) interval (can be less than 10 subframes, e.g. 1ms) is introduced to reduce uplink latency for SPS.*
* *Uplink skipping mechanism is introduced for SPS to avoid resource release such that the latency of waiting for the next SPS uplink grant can be avoided.*

*mMTC services are supported by NB-IoT / eMTC** *DFT-spreading and Pi/2 BPSK and Pi/4 QPSK modulation in NB-IoT for reduced PAPR for better coverage*
* *Repetition of a transmission for both control and data for better coverage*
* *High-aggregation level downlink control for better coverage*
* *Small data transmission during random access without moving to RRC connected mode for optimized signalling overhead*
* *PSM mode for non-pagable UEs and extended DRX cycle for RRC IDLE mode to improve battery life*
* *Support for narrow-band (low-cost) UEs within a wide-band carrier system*
* *Support for single sub-carrier uplink transmission in NB-IoT to increase connections and extend coverage*

*LTE is capable of deploying a range of services, e.g., mMTC and eMBB services, on a single continuous block of spectrum, by e.g., eMTC in-band operation or NB-IoT with in-band / guard-band operation (see item 5.2.3.2.8.1 for more details).* |
| **5.2.3.2.24** | **Global circulation of terminals**Describe technical basis for global circulation of terminals not causing harmful interference in any country where they circulate, including a case when terminals have capability of device-to-device direct communication mode.*The information will be provided in later update* |
| **5.2.3.2.25** | **Energy efficiency**Describe how the RIT/SRIT supports a high sleep ratio and long sleep duration.Describe other mechanisms of the RIT/SRIT that improve the support of energy efficiency operation for both network and device.*The information will be provided in later update* |
| **5.2.3.2.26** | **Other items**  |
| 5.2.3.2.26.1 | *Coverage extension schemes*Describe the capability to support/ coverage extension schemes, such as relays or repeaters.*The information will be provided in later update.* |
| 5.2.3.2.26.2 | *Self-organisation* Describe any self-organizing aspects that are enabled by the RIT/SRIT.*The information will be provided in later update.* |
| 5.2.3.2.26.3 | Describe the frequency reuse schemes (including reuse factor and pattern) for the assessment of average spectral efficiency and 5th percentile user spectral efficiency.*The information will be provided in later update.* |
| 5.2.3.2.26.4 | Is the RIT/component RIT an evolution of an existing IMT technology? Provide the detail.*The information will be provided in later update.* |
| 5.2.3.2.26.5 | Does the proposal satisfy a specific spectrum mask? Provide the detail. (This information is not intended to be used for sharing studies.)*The information will be provided in later update.* |
| 5.2.3.2.26.6 | Describe any UE power saving mechanisms used in the RIT/SRIT. *The information will be provided in later update.* |
| 5.2.3.2.26.7 | *Simulation process issues*Describe the methodology used in the analytical approach.Proponent should provide information on the width of confidence intervals of user and system performance metrics of corresponding mean values, and evaluation groups are encouraged to provide this information as requested in § 7.1 of Report ITU-R M.2412-0.*The information will be provided with self evaluation.* |
| 5.2.3.2.26.8 | *Operational life time*Describe the mechanisms to provide long operational life time for devices without recharge for at least massive machine type communications*The information will be provided in later update.* |
| 5.2.3.2.26.9 | *Latency for infrequent small packet* Describe the mechanisms to reduce the latency for infrequent small packet, which is, in a transfer of infrequent application layer small packets/messages, the time it takes to successfully deliver an application layer packet/message from the radio protocol layer 2/3 SDU ingress point at the UE to the radio protocol layer 2/3 SDU egress point in the base station, when the UE starts from its most "battery efficient" state.*The information will be provided in later update.* |
| 5.2.3.2.26.10 | *Control plane latency*Provide additional information whether the RIT/SRIT can support a lower control plane latency (refer to § 4.7.2 in Report ITU-R M.2410-0).*The information will be provided in later update.* |
| 5.2.3.2.26.11 | *Reliability*Provide additional information whether the RIT/RSIT can support reliability for larger packet sizes (refer to § 4.10 in Report ITU-R M.2410-0).*The information will be provided in later update.* |
| 5.2.3.2.26.12 | *Mobility*Provide additional information for the downlink mobility performance of the RIT/SRIT (refer to § 4.11 in Report ITU-R M.2410-0).*The information will be provided in later update.* |
| **5.2.3.2.27** | **Other information**Please provide any additional information that the proponent believes may be useful to the evaluation process.*The information will be provided in later update, if any.* |

**Reference**

[22.261] TS22.261v16.1.0 “Service requirements for next generation new services and markets”

[36.101] TS36.101v15.1.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception”

[36.133] TS36.133v15.1.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management”

[36.201] TS36.201v14.1.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); LTE physical layer; General description”

[36.211] TS36.211v15.0.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation”

[36.212] TS36.212v15.0.1 “Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding”

[36.213] TS36.213v15.0.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures”

[36.300] TS36.300v15.0.0 “Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2”

[36.304] TS36.304v14.5.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode”

[36.321] TS36.321v15.0.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification”

[36.322] TS36.322v15.0.0 “Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification”

[36.401] TS36.401v15.0.0 “Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Architecture description”

[37.340] TS37.340v15.0.0 “NR; Multi-connectivity; Overall description; Stage-2”

[38.101] TS38.101v15.0.0 “NR; User Equipment (UE) radio transmission and reception”

[38.133] TS38.133v15.0.0 “NR; Requirements for support of radio resource management”

[38.201] TS38.201v15.0.0 “NR; Physical layer; General description”

[38.211] TS38.211v15.0.0 “NR; Physical channels and modulation”

[38.212] TS38.212v15.0.0 “NR; Multiplexing and channel coding”

[38.213] TS38.213v15.0.0 “NR; Physical layer procedures for control”

[38.214] TS38.214v15.0.0 “NR; Physical layer procedures for data”

[38.215] TS38.215v15.0.0 “NR; Physical layer measurements”

[38.300] TS38.300v15.0.0 “NR; Overall description; Stage-2”

[38.304] TS38.304v0.0.7 “NR; User Equipment (UE) procedures in idle mode”

[38.321] TS38.321v15.0.0 “NR; Medium Access Control (MAC) protocol specification”

[38.322] TS38.322v15.0.0 “NR; Radio Link Control (RLC) protocol specification”

[38.401] TS38.401v15.0.0 “NG-RAN; Architecture description”

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1. Developed by 3GPP as 5G, Release 15 and beyond. [↑](#footnote-ref-1)