

3GPP TR 38.822 V15.0.1 (2019-07)

Technical Report

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; NR; User Equipment (UE) feature list (Release 15)



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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

- x the first digit:
 - 1 presented to TSG for information;
 - 2 presented to TSG for approval;
 - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, certain modal verbs have the following meanings:

- shall** indicates a mandatory requirement to do something
- shall not** indicates an interdiction (prohibition) to do something

NOTE 1: The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

NOTE 2: The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

- should** indicates a recommendation to do something
- should not** indicates a recommendation not to do something
- may** indicates permission to do something

need not indicates permission not to do something

NOTE 3: The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

can indicates that something is possible

cannot indicates that something is impossible

NOTE 4: The constructions "can" and "cannot" shall not to be used as substitutes for "may" and "need not".

will indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

will not indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

might indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

might not indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

is (or any other verb in the indicative mood) indicates a statement of fact

is not (or any other negative verb in the indicative mood) indicates a statement of fact

NOTE 5: The constructions "is" and "is not" do not indicate requirements.

1 Scope

The present document provides the list of UE features for NR. For each NR UE feature, the corresponding field name of UE capability, as specified in TS 38.331 [2] is also captured in this document. The Release 15 UE feature list described in clause 4 reflects the status of Release 15 in June 2019 and has not been maintained after this date.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) protocol specification".
- [3] 3GPP R1-1907862: "RAN1 NR UE features", contribution to TSG-RAN WG1 meeting #XX.
- [4] 3GPP R2-1906665: "Update of L2/3 feature lists", contribution to TSG-RAN WG2 meeting #105bis.
- [5] 3GPP R4-1907593: "RAN4 NR UE features", contribution to TSG-RAN WG4 meeting #XX.

3 Definitions of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

example: text used to clarify abstract rules by applying them literally.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

4Release 15 UE feature list

4.1 Layer-1 UE features

Table 4.1-1 provides the list of Layer-1 features, as shown in [3] and the corresponding UE capability field name, as specified in TS 38.331 [2].

Table 4.1-1: Layer-1 feature list

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Features	Index	Feature group	Components	Prerequisite feature groups	Field name in TS 38.331 [2]	Parent IE in TS 38.331 [2]	Need of FDD/TDD differentiation	Need of FR1/FR2 differentiation	Note	Mandatory/Optional	
0. Waveform, modulation, subcarrier spacings, and CP	0-1	CP-OFDM waveform for DL and UL	1) CP-OFDM for DL	1-1 in Table 4.3-1	n/a	n/a	n/a	n/a	Broadcast SIB reception including RMSI/OSI and paging are components of basic initial access channels and procedures for NR standalone and NE-DC	Mandatory without capability signalling	
	0-2	DFT-S-OFDM waveform for UL	2) CP -OFDM for UL Transform precoding for single-layer PUSCH		n/a	n/a	n/a	n/a		Mandatory without capability signalling	
	0-3	DL modulation scheme	1) QPSK modulation 2) 16QAM modulation 3) 64QAM modulation for FR1		n/a	n/a	n/a	n/a		Mandatory without capability signalling	
	0-4	UL modulation scheme	1) QPSK modulation 2) 16QAM modulation		n/a	n/a	n/a	n/a		Mandatory without capability signalling	
	0-5	Extended CP	Extended CP		<i>extendedCP</i>	<i>BandNR</i>	n/a	n/a		Optional with capability signalling	
1. Initial access and mobility	1-1	Basic initial access channels and procedures	1) RACH preamble format 2) SS block based RRM measurement 3) Broadcast SIB reception including RMSI/OSI and paging		n/a	n/a	No	No		Mandatory without capability signalling	
	1-2	SS block based SINR measurement (SS-SINR)	SS-SINR measurement	1-1	<i>ss-SINR-Meas</i>	<i>MeasAndMobParametersFRX-Diff</i>	No	Yes		Optional with capability signalling	
	1-3	SS block based RLM	SS block based RLM	1-1	<i>ssb-RLM</i>	<i>MeasAndMobParametersCommon</i>	No	No		Mandatory with capability signalling which shall be set to '1'	
	1-4	CSI-RS based RRM measurement with associated SS-block	1) CSI-RSRP measurement 2) CSI-RSRQ measurement	1-1, CSI-RS	<i>csi-RSRP-AndRSRQ-MeasWithSSB</i>	<i>MeasAndMobParametersFRX-Diff</i>	No	Yes	This does not discourage RAN4 to complete their work. There is expectation that RAN4 will complete the corresponding RRM measurement	Optional with capability signalling	
	1-5	CSI-RS based RRM measurement without associated SS-block	1) CSI-RSRP measurement 2) CSI-RSRQ measurement 3) There is SS-block in the target frequency on which the RRM measurement is performed	1-1, CSI-RS	<i>csi-RSRP-AndRSRQ-MeasWithoutSSB</i>	<i>MeasAndMobParametersFRX-Diff</i>	No	Yes	This does not discourage RAN4 to complete their work. There is expectation that RAN4 will complete the corresponding RRM measurement	Optional with capability signalling	
	1-6	CSI-RS based RS-SINR measurement	CSI-SINR measurements	1-1, 1-4	<i>csi-SINR-Meas</i>	<i>MeasAndMobParametersFRX-Diff</i>	No	Yes		Optional with capability signalling	
	1-7	CSI-RS based RLM	CSI-RS based RLM	1-1, CSI-RS	<i>csi-RS-RLM</i>	<i>MeasAndMobParametersFRX-Diff</i>	No	Yes		Mandatory with capability signalling	
	1-8	RLM based on a mix of SS block and CSI-RS signals within active BWP	RLM based on a mix of SS block and CSI-RS signals within active BWP	1-3 and 1-7	<i>ssb-AndCSI-RS-RLM</i>	<i>MeasAndMobParametersCommon</i>	No	No		Optional with capability signalling	
	1-9	CSI-RS based contention free RA for HO	CSI-RS based contention free RA for HO	1-1, CSI-RS, 1-4 or 1-5	<i>csi-RS-CFRA-ForHO</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling	
	1-10	Support of SCell without SS/PBCH block	Support SCell without SS/PBCH block	1-1	<i>sceIIWithoutSSB</i>	<i>FeatureSetDownlink</i>	n/a	n/a	Component 1) Whether or not UE is able to use SS/PBCH block from other Cells for time/frequency synchronization of SCell without SS/PBCH block	Mandatory with capability signalling for intra-band CA This feature is not supported for inter band CA	

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2. MIMO	1-11	Support of CSI-RS RRM measurement for SCell without SS/PBCH block	1-10	<i>csi-RS-MeasSCellWithoutSSB</i>	<i>FeatureSetDownlink</i>	n/a	n/a		Optional with capability signalling	
	1-12	E-UTRA RS-SINR measurement		<i>rs-SINR-MeasEUTRA</i>	<i>EUTRA-ParametersCommon</i>	No	No		Optional with capability signalling	
	1-13	Maximal number of CSI-RS resources for RRM and RS-SINR measurement across all measurement frequencies per slot	1-4 or 1-5 or 1-6	<i>maxNumberCSI-RS-RRM-RS-SINR</i>	<i>MeasAndMobParametersCommon</i>	No	No	If UE supports any of 1-5, 1-5a, and 1-6, UE shall report this capability 1-13	Candidate value set: {4,8,16,32,64, 96}	
	1-14	Maximal number of CSI-RS resources within a slot per PCell/PSCell for CSI-RS based RLM	1-7 or 1-8	<i>maxNumberResource-CSI-RS-RLM</i>	<i>MeasAndMobParametersFRX-Diff</i>	No	Yes	If UE supports any of 1-7 and 1-8, UE shall report this capability 1-14	Candidate value set: {2,4, 6, 8}	
	2-1	Basic PDSCH reception		n/a	n/a	n/a	n/a		Mandatory without capability signalling	
	2-2	PDSCH beam switching	2-1	<i>timeDurationForQCL</i>	<i>FeatureSetDownlink</i>	No	Applicable only to FR2		Mandatory with capability signalling for FR2 Candidate value set for X1 is {7, 14, 28}, Candidate value set for X2, {14, 28}	
	2-3	PDSCH MIMO layers	2-1	<i>maxNumberMIMO-LayersPDSCH</i>	<i>FeatureSetDownlinkPerCC</i>	n/a	n/a		For single CC standalone NR, it is mandatory with capability signalling to support at least 4 MIMO layers in the bands where 4Rx is specified as mandatory for the given UE and at least 2 MIMO layers in FR2. Some relaxations to this requirement may be applicable in the future (including in Rel-15). Mandatory in all cases means mandatory with capability signalling. It is not expected that there is a signalling change (i.e. signalling remains to be defined as {1, 2, 4, 8} in every band and every band combination, including FR1 and FR2 in all cases.	

2-4	TCI states for PDSCH	1) Support number of active TCI states per BWP per CC, including control and data 2) Maximum number of configured TCI states per CC for PDSCH	2-1	<i>tci-StatePDSCH</i> { 1. <i>maxNumberActiveTCI-PerBWP</i> 2. <i>maxNumberConfiguredTCIstatesPerCC</i> }	<i>MIMO-ParametersPerBand</i>	n/a	n/a	UE is required to track only the active TCI states For component 1 of FG2-4, if a UE reports X active TCI state(s), it is not expected that more than X active QCL type D assumption(s) for any PDSCH and any CORESETs for a given BWP of a serving cell become active for the UE. Only applicable if Component-1 of 2-4 is set to 1	Mandatory with capability signalling Component-1: Candidate value set: {1, 2, 4, 8} Component-2: candidate value set: {4, 8, 16, 32, 64, 128} UE is mandated to signal 64 for FR2. For FR1, UE is mandated to report at least the max number of allowed SSB in the band.
2-4a	Additional active TCI state for PDCCH	Support one additional active TCI state for control in addition to the supported number of active TCI states for PDSCH	2-1	<i>additionalActiveTCI-StatePDCCH</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Mandatory with capability signalling
2-5	Basic downlink DMRS for scheduling type A	1) Support 1 symbol FL DMRS without additional symbol(s) 2) Support 1 symbol FL DMRS and 1 additional DMRS symbol 3) Support 1 symbol FL DMRS and 2 additional DMRS symbols for at least one port.	2-1	n/a	n/a	n/a	n/a	conditioned to whether PDSCH scheduling type A is supported	Mandatory without capability signalling (condition to scheduling capability)
2-6	Basic downlink DMRS for scheduling type B	1) Support 1 symbol FL DMRS without additional symbol(s) 2) Support 1 symbol FL DMRS and 1 additional DMRS symbol		n/a	n/a	n/a	n/a	conditioned to whether PDSCH scheduling type B is supported	Mandatory without capability signalling (condition to scheduling capability)
2-6a	Support 1+2 DMRS (downlink)	Support 1 symbol FL DMRS and 2 additional DMRS symbols for more than one port	2-5	<i>oneFL-DMRS-TwoAdditionalDMRS-DL</i>	<i>FeatureSetDownlink-v1540</i>	No	Yes		Mandatory with capability signalling
2-6b	Support alternative additional DMRS location	Support alternative additional DMRS position for co-existence with LTE CRS	2-5 and 5-28	<i>additionalDMRS-DL-Alt</i>	<i>FeatureSetDownlink-v1540</i>	No	n/a	This FG applies to FR1 only and 15kHz SCS. This applies to one additional DMRS case only	Optional with capability signalling
2-7	Supported 2 symbols front-loaded DMRS (downlink)	Support 2 symbols FL-DMRS	2-5	<i>twoFL-DMRS</i> (MSB)	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
2-8	Supported 2 symbols front-loaded +2 symbols additional DMRS (downlink)	Support 2-symbol FL DMRS + one additional 2-symbols DMRS	2-5	<i>twoFL-DMRS-TwoAdditionalDMRS-DL</i>	<i>FeatureSetDownlink-v1540</i>	No	Yes		Optional with capability signalling
2-9	Support 1+3 DMRS symbols(downlink)	Support 1 symbol FL DMRS and 3 additional DMRS symbols	2-5	<i>oneFL-DMRS-ThreeAdditionalDMRS-DL</i>	<i>FeatureSetDownlink-v1540</i>	No	Yes		Optional with capability signalling
2-10	Support DMRS type (downlink)	Support DMRS {type 1, both type 1 and type 2}		<i>supportedDMRS-TypeDL</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Type 1 is mandatory with capability signalling.
2-11	Downlink dynamic PRB bundling (downlink)	Support dynamic PRB bundling indication via DCI	2-1	<i>dynamicPRB-BundlingDL</i>	<i>Phy-ParametersCommon</i>	No	No	Support of semi-static PRB bundling is mandatory	Type 2 is optional with capability signalling Optional with capability signalling

2-12	Basic PUSCH transmission	Data RE mapping Single layer (single Tx) transmission Single port, single resource SRS transmission (SRS set use is configured as for codebook)	n/a		n/a		n/a	n/a	Support of SRS set usage configured as for codebook does not imply UE support of codebook based PUSCH MIMO transmission.	Mandatory without capability signalling
2-13	PUSCH codebook coherency subset	Supported codebook coherency subset type	2-12	<i>pusch-TransCoherence</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a			Optional with UE capability Candidate value set: {non-coherent, partial/non-coherent, full/partial/non-coherent}
2-14	Codebook based PUSCH MIMO transmission	1) Supported codebook based PUSCH MIMO with maximal number of supported layers 2) Supported max number of SRS resource per set (SRS set use is configured as for codebook).	2-13	<i>mimo-CB-PUSCH { 1. <i>maxNumberMIMO-LayersCB-PUSCH</i> 2. <i>maxNumberSRS-ResourcePerSet</i> }</i>	<i>FeatureSetUplinkPerCC</i>	n/a	n/a	For SUL, uplink MIMO is not supported.		Optional with UE capability Component-1: Candidate value: {no-codebook based MIMO, 1, 2, 4} Component-2 Candidate value: {1, 2}
2-15	non-codebook based PUSCH transmission	1) Maximal number of supported layers (non-codebook transmission scheme) 2) Supported max number of SRS resource per set (SRS set use is configured as for non-codebook transmission). 3) Maximum number of simultaneous transmitted SRS resources at one symbol	2-12	1. <i>maxNumberMIMO-LayersNonCB-PUSCH</i> <i>mimo-NonCB-PUSCH { 2. <i>maxNumberSRS-ResourcePerSet</i> 3. <i>maxNumberSimultaneousSRS-ResourceTx</i> }</i>	1. <i>FeatureSetUplinkPerCC</i> 2, 3. <i>FeatureSetUplinkPerCC-v1540</i>	n/a	n/a	For SUL, uplink MIMO is not supported		Optional with UE capability Component-1 candidate values: {1, 2, 4} Component-2 Candidate value: {1,2,3,4} Component-3 Candidate value: {1,2,3,4}
2-15a	Association between CSI-RS and SRS	1) Support association between NZP-CSI-RS and SRS resource set via RRC parameter "SRSresoureset" 2) A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} across all CCs simultaneously.	2-15	<i>srs-AssocCSI-RS SEQUENCE (SIZE (1..<i>maxNrofCSI-RS-Resources</i>)) OF { 2.1. <i>maxNumberOfPortsPerResource</i> 2.2. <i>maxNumberResourcesPerBand</i> 2.3. <i>totalNumberOfPortsPerBand</i> }</i> <i>csi-RS-IM-ReceptionForFeedbackPerBandComb { 2.2. <i>maxNumberSimultaneousNZP-CSI-RS-ActBWP-AIICC</i> 2.3. <i>totalNumberPortsSimultaneousNZP-CSI-RS-ActBWP-AIICC</i> }</i>	<i>MIMO-ParametersPerBand</i> <i>CA-ParametersNR-v1540</i>	n/a	n/a			Optional with capability signalling Component-2: Maximum size of the list is 16. the candidate values for the max # of Tx port in one resource is {2, 4, 8, 12, 16, 24, 32} The candidate value set of the max # of resources is: {from 1 to 64} The candidate value set of total # of ports is: {from 2 to 256}

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2-15b	CSI-RS processing framework for SRS	1) Maximum number of periodic SRS resources associated with CSI-RS per BWP 2) Maximum number of aperiodic SRS resources associated with CSI-RS per BWP 3) Maximum number of semi-persistent SRS resources associated with CSI-RS per BWP 4) UE can process Y SRS resources associated with CSI-RS resources simultaneously in a CC. Includes P/SP/A SRS. 5) UE can process X SRS resources associated with CSI-RS resources simultaneously across all CCs. Includes P/SP/A SRS.	2-15a	<i>csi-RS-ProcFrameworkForSRS</i> { 1. <i>maxNumberPeriodicSRS-AssocCSI-RS-PerBWP</i> 2. <i>maxNumberAperiodicSRS-AssocCSI-RS-PerBWP</i> 3. <i>maxNumberSP-SRS-AssocCSI-RS-PerBWP</i> 4. <i>simultaneousSRS-AssocCSI-RS-PerCC</i> } <							

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2-20	Beam correspondence	Support Beam correspondence	<i>beamCorrespondenceWithoutUL-BeamSweeping</i>	<i>MIMO-ParametersPerBand</i>	No	Applicable only to FR2	Beam correspondence means each Tx port can be beamformed in a desirable direction but does not imply setting phase across ports.	Mandatory with capability signalling - UE that fulfils the beam correspondence requirement without the uplink beam sweeping shall set the bit to 1 - UE that fulfils the beam correspondence requirement with the uplink beam sweeping shall set the bit to 0	
2-21	Periodic beam report	1) Support report on PUCCH formats over 1 – 2 OFDM symbols once per slot 2) Support report on PUCCH formats over 4 – 14 OFDM symbols once per slot	<i>periodicBeamReport</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Mandatory with capability signalling for both FR1 and FR2	
2-22	Aperiodic beam report	Support aperiodic report on PUSCH	<i>aperiodicBeamReport</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Mandatory with capability signalling for both FR1 and FR2	
2-23	Semi-persistent beam report on PUCCH	1) Support report on PUCCH formats over 1 – 2 OFDM symbols once per slot (or piggybacked on a PUSCH) 2) Support report on PUCCH formats over 4 – 14 OFDM symbols once per slot (or piggybacked on a PUSCH)	<i>sp-BeamReportPUCCH</i>	<i>MIMO-ParametersPerBand</i>	n/a	Yes		Optional with capability signalling	
2-23a	Semi-persistent beam report on PUSCH	Support semi-persistent report on PUSCH	<i>sp-BeamReportPUSCH</i>	<i>MIMO-ParametersPerBand</i>	n/a	Yes		Optional with capability signalling	

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2-24	SSB/CSI-RS for beam measurement	1) The max number of SSB/CSI-RS (1Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured to measure L1-RSRP within a slot shall not exceed MB_1 2) The max number of CSI-RS resources (sum of aperiodic/periodic/semi-persistent) across all CCs configured to measure L1-RSRP shall not exceed MC_1 3) The max number of CSI-RS (2Tx) resources (sum of aperiodic/periodic/semi-persistent) across all CCs to measure L1-RSRP within a slot shall not exceed MB_2 4) Supported density of CSI-RS 5) The max number of aperiodic CSI-RS resources across all CCs configured to measure L1-RSRP shall not exceed MD_1	2-21, 2-22 or 2-23, 2-23a	<i>beamManagementSSB-CSI-RS</i> { 1. <i>maxNumberSSB-CSI-RS-ResourceOneTx</i> 2. <i>maxNumberCSI-RS-Resource</i> 3. <i>maxNumberCSI-RS-ResourceTwoTx</i> 4. <i>supportedCSI-RS-Density</i> 5. <i>maxNumberAperiodicCSI-RS-Resource</i> }	<i>MIMO-ParametersPerBand</i>	No	Yes	Mandatory with capability signalling Component-1, candidate value set for MB_1 is {0, 8, 16, 32, 64} On FR2, UE is mandated to signal MB_1 >=8 On FR1, MB_1 >=8 is supported mandatory with capability signalling. Component-2, candidate value set for MC_1 is {0, 4, 8, 16, 32, 64} For FR1, UE is mandated to report at least 8. Component-3, candidate value set for MB_2 is {0, 4, 8, 16, 32, 64} Component-4: candidate value set: {"not supported", "1 only", "3 only", "both 1 and 3"} On FR2, UE is mandated to signal either "3 only" or "both 1 and 3" On FR1, either "3 only" or "both 1 and 3" is mandatory with UE capability signalling. Component-5, candidate value set for MD_2 is {0, 1, 4, 8, 16, 32, 64} For both FR1 and FR2, UE is mandated to report at least 4	
2-25	Beam reporting timing	The number of symbols, Xi, between the last symbol of SSB/CSI-RS and the first symbol of the transmission channel containing beam report is at least RBi, where i is the index of SCS, i=1,2,3,4 corresponding to 15,30,60,120 kHz SCS.	2-24	<i>beamReportTiming</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a	Mandatory with capability Candidate value sets: X1 is {2, 4, 8} X2 is {4, 8, 14, 28} X3 is {8,14, 28} X4 is{14,28, 56}	

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2-26	Receiving beam selection using CSI-RS resource repetition "ON"	1. Support Rx beam switching procedure using CSI-RS resource repetition "ON"		<i>maxNumberRxBeam</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Mandatory with UE capability at least for FR2	
2-27	Beam switching	2. Recommended CSI-RS resource repetition number per resource set, Maximum number of Tx + Rx beam changes a UE can conduct during a slot across the whole band CC B_(B_Total,). This number is defined as per SCS	2-24	<i>maxNumberRxTxBeamSwitchDL</i>	<i>MIMO-ParametersPerBand</i>	n/a	Applicable only to FR2	It is assumed that spec enable the possibility to restrict the same beam across intra-band CCs	Componet-2: candidate value set {2, 3, 4, 5, 6, 7, 8} Optional with capability signalling Candidate value set: {4, 7, 14}	
2-28	A-CSI-RS beam switching timing	Minimum time between the DCI triggering of AP-CSI-RS and aperiodic CSI-RS transmission shall be at least K _{Bi} symbols. (Symbols measured from last symbol containing the indication to first symbol of CSI-RS), where i is the index of SCS, I=1,2 corresponding to 60,120 kHz SCS.		<i>beamSwitchTiming</i>	<i>MIMO-ParametersPerBand</i>	n/a	Applicable only to FR2		Optional with capability signalling	
2-29	Non-group based beam reporting	Support of non-group based RSRP reporting with N_max RSRP values reported		<i>maxNumberNonGroupBeamReporting</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Mandatory with capability for both FR1 and FR2 candidate value set is {1, 2, 4}	
2-29a	Group based beam reporting	Support of beam group RSRP reporting for group of 2 beams		<i>groupBeamReporting</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Optional with capability signalling	
2-30	Uplink beam management	1) Support of SRS based beam management 2) Supported max number of SRS resource per set (SRS set use is configured as for beam management). 3) Supported max number of SRS resource sets (SRS set use is configured as for beam management).		<i>uplinkBeamManagement</i> { 2. <i>maxNumberSRS-ResourcePerSet-BM</i> 3. <i>maxNumberSRS-ResourceSet</i> }	<i>MIMO-ParametersPerBand</i>	n/a	n/a	Component-3 also impose additional constraint on the maximum number of SRS resource sets per supported time domain behaviour (periodic/semi-persistent/aperiodic) as {1,1,1,2,2,2,4,4} corresponding to reported values {from 1 to 8}	Optional with capability signalling - Capability signalling shall be set to 1 if 2-20 is set to 0 - For the UE meeting the minimum peak EIRP and spherical coverage requirements without the uplink beam sweeping, this feature is optional	
									Component-2, candidate value set is {2, 4, 8, 16} Component-3, candidate value set is {from 1 to 8}	

2-31	Beam failure recovery	1) Maximal number of CSI-RS resources across all CCs for UE to monitor PDCCH quality 2) Maximal number of different SSBs across all CCs for UE to monitor PDCCH quality 3) Maximal number of different CSI-RS and/or SSB resources across all CCs for new beam identifications.	1-7 for CSI-RS based BFD/BFR	1. <i>maxNumberCSI-RS-BFD</i> 2. <i>maxNumberSSB-BFD</i> 3. <i>maxNumberCSI-RS-SSB-CBD</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a	Mandatory with capability signalling for FR2 Optional with capability signalling for FR1 Component-1 candidate value set: {from 1 to 16} Component-2 candidate: {from 1 to 16} Component-3: Candidate value set is: {from 1 to 128} UE is mandated to support at least 32 for FR2
2-32	Basic CSI feedback	1) Type I single panel codebook based PMI (further discuss which mode or both to be supported as mandatory) 2) 2Tx codebook for FR1 and FR2 3) 4Tx codebook for FR1 4) 8Tx codebook for FR1 when configured as wideband CSI report 5) p-CSI on PUCCH formats over 1 – 2 OFDM symbols once per slot (or piggybacked on a PUSCH) 6) p-CSI report on PUCCH formats over 4 – 14 OFDM symbols once per slot (or piggybacked on a PUSCH) 7) a-CSI on PUSCH (at least Z value >= 14 symbols, detail processing time to be discussed separately) further check a-CSI on p-CSI-RS and/or SP-CSI-RS from component-7		n/a	n/a	n/a	n/a	Mandatory without capability signalling
2-32a	Semi-persistent CSI report on PUCCH	1) Support report on PUCCH formats over 1 – 2 OFDM symbols once per slot (or piggybacked on a PUSCH) s 2) Support report on PUCCH formats over 4 – 14 OFDM symbols once per slot (or piggybacked on a PUSCH)		<i>sp-CSI-ReportPUCCH</i>	<i>Phy-ParametersCommon</i>	No	No	Optional with capability signalling
2-32b	Semi-persistent CSI report on PUSCH	Support semi-persistent CSI report on PUSCH		<i>sp-CSI-ReportPUSCH</i>	<i>Phy-ParametersCommon</i>	No	No	Optional with capability signalling
2-32c	New CQI table	CQI table with target BLER of 10 ⁻⁵		<i>cqi-TableAlt</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	Optional with capability signalling

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2-35	CSI report framework	<p>1) Maximum number of periodic CSI report setting per BWP for CSI report</p> <p>2) Maximum number of periodic CSI report setting per BWP for beam report</p> <p>3) Maximum number of aperiodic CSI report setting per BWP for CSI report</p> <p>4) Maximum number of aperiodic CSI report setting per BWP for beam report</p> <p>5) Maximum number of configured aperiodic CSI triggering states in <i>CSI-AperiodicTriggerStateList</i> per CC,</p> <p>6) Maximum number of semi-persistent CSI report setting per BWP for CSI report</p> <p>7) Maximum number of semi-persistent CSI report setting per BWP for beam report</p> <p>8) UE can process Y CSI report(s) simultaneously in a CC. CSI reports can be P/SP/A CSI and any latency class and codebook type.</p> <p>9) UE can process X CSI report(s) simultaneously across all CCs. CSI reports can be P/SP/A CSI and any latency class and codebook type.</p>	2-32	<p><i>csi-ReportFramework</i> {</p> <p>1. <i>maxNumberPeriodicCSI-PerBWP-ForCSI-Report</i></p> <p>2. <i>maxNumberAperiodicCSI-PerBWP-ForCSI-Report</i></p> <p>3. <i>maxNumberSemiPersistentCSI-PerBWP-ForCSI-Report</i></p> <p>4. <i>maxNumberPeriodicCSI-PerBWP-ForBeamReport</i></p> <p>5. <i>maxNumberAperiodicCSI-PerBWP-ForBeamReport</i></p> <p>6. <i>maxNumberAperiodicCSI-triggeringStatePerCC</i></p> <p>7. <i>maxNumberSemiPersistentCSI-PerBWP-ForBeamReport</i></p> <p>8. <i>simultaneousCSI-ReportsPerCC</i></p> <p>}</p> <p>9. <i>simultaneousCSI-ReportsAllCC</i></p>	<p><i>MIMO-ParametersPerBand</i></p> <p><i>Phy-ParametersFRX-Diff</i> (for FR1 + FR2 band combination)</p> <p><i>CA-ParametersNR-v1540</i></p>	n/a	n/a	<p>Other MIMO capabilities than component 5 may further restrict (reduce) the number of simultaneously CSI report that UE is required to update</p> <p>The CSI report in component 4 and 5 includes the beam report and CSI report</p> <p>Each component is independent</p> <p>CSI report setting are counted in the CC indicated by the parameter carrier in <i>CSI-ResourceConfig</i>.</p>	<p>Mandatory with capability signaling</p> <p>Component-1 candidate values: {1, 2, 3, 4}</p> <p>Component-1a candidate values: {1, 2, 3, 4}</p> <p>Component-2 candidate values {1, 2, 3, 4}</p> <p>Component-2a candidate values {1, 2, 3, 4}</p> <p>Component-2b candidate values {3, 7, 15, 31, 63, 128}</p> <p>Component-3 candidate values: {0, 1, 2, 3, 4}</p> <p>Component-3a candidate values: {0, 1, 2, 3, 4}</p> <p>Component-4 candidate values: {from 1 to 8}</p> <p>Component-5: candidate values: {from 5 to 32}</p>
2-36	Type I single panel codebook	<p>1) A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} across all CCs simultaneously. Note: the above list doesn't differentiate the latency class and feedback type.</p> <p>2) Supported Codebook Mode(s)</p> <p>3) Max # of CSI-RS resource in a resource set</p>	2-35	<p>1. <i>supportedCSI-RS-ResourceList SEQUENCE (SIZE (1..maxNrofCSI-RS-Resources)) OF</i> {</p> <p>1.1. <i>maxNumberTxPortsPerResource</i></p> <p>1.2. <i>maxNumberResourcesPerBand</i></p> <p>1.3. <i>totalNumberTxPortsPerBand</i></p> <p>}</p> <p>2. <i>modes</i></p> <p>3. <i>maxNumberCSI-RS-PerResourceSet</i></p> <p><i>csi-RS-IM-ReceptionForFeedbackPerBandComb</i> {</p> <p>1.2. <i>maxNumberSimultaneousNZP-CSI-RS-ActBWP-AllCC</i></p> <p>1.3. <i>totalNumberPortsSimultaneousNZP-CSI-RS-ActBWP-AllCC</i></p> <p>}</p>	<p><i>CodebookParameters</i></p> <p><i>CA-ParametersNR-v1540</i></p>	No	n/a	<p>Simultaneously doesn't mean in the same slot</p> <p>For the purpose of component-1 calculation: CSI-RS resources and CSI-RS ports within one CSI-RS resource are counted N times if the CSI-RS resource is referred by N report settings.</p>	<p>Mandatory with capability signalling</p> <p>Component-1: Maximum size of the list is 16. the candidate values for the max # of Tx port in one resource is {2, 4, 8, 12, 16, 24, 32}</p> <p>The candidate value set of the max # of resources is: {from 1 to 64}</p> <p>The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is: {from 2 to 256}</p> <p>Component-2 candidate values: {"Mode-1 only", "Mode-1 and Mode-2"}.</p> <p>Component-3 Candidate values set: {1:8}</p>

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2-37	Support Semi-open loop CSI	Support Semi-open loop CSI report	2-35	<i>semiOpenLoopCSI</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	Simultaneously doesn't mean in the same slot	Optional with capability signalling				
2-38	CSI report without PMI	Support CSI report without PMI	2-35	<i>csi-ReportWithoutPMI</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes			Optional with capability signalling			
2-39a	CSI report without CQI	Support CSI report without CQI	2-35	<i>csi-ReportWithoutCQI</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes				Optional with capability signalling		
2-40	Type I multi-panel codebook	1) A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} across all CCs simultaneously. Note: the above list doesn't differentiate the latency class and feedback type. 2) Supported Codebook Mode(s): 3) Supported number of panels, Ng 4) Max # of CSI-RS resource in a resource set	2-35	1. <i>supportedCSI-RS-ResourceList SEQUENCE (SIZE (1..maxNrofCSI-RS-Resources)) OF {</i> 1.1. <i>maxNumberTxPortsPerResource</i> 1.2. <i>maxNumberResourcesPerBand</i> 1.3. <i>totalNumberTxPortsPerBand</i> <i>}</i> 2. <i>modes</i> 3. <i>nrofPanels</i> 4. <i>maxNumberCSI-RS-PerResourceSet</i>	<i>CodebookParameters</i>	n/a	n/a					Simultaneously doesn't mean in the same slot	Optional with capability signalling
				<i>csi-RS-IM-ReceptionForFeedbackPerBandComb {</i> 1.2. <i>maxNumberSimultaneousNZP-CSI-RS-ActBWP-AIICC</i> 1.3. <i>totalNumberPortsSimultaneousNZP-CSI-RS-ActBWP-AIICC</i> <i>}</i>	<i>CA-ParametersNR-v1540</i>			For the purpose of component-1 calculation: CSI-RS resources and CSI-RS ports within one CSI-RS resource are counted N times if the CSI-RS resource is referred by N report settings.	Component-1: Maximum size of the list is 16. the candidate values for the max # of Tx port in one resource is {8, 16, 32} The candidate value set of the max # of resources is: {from 1 to 64} The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is: {from 2 to 256} Component-2 candidate values: {Mode-1, Mode-2, both} Component-3: Candidate value: {2,4} Component-4: candidate value set is {1:8}				
2-41	Type II codebook		2-35	1. <i>supportedCSI-RS-ResourceList SEQUENCE (SIZE (1..maxNrofCSI-RS-Resources)) OF {</i> 1.1. <i>maxNumberTxPortsPerResource</i> 1.2. <i>maxNumberResourcesPerBand</i> 1.3. <i>totalNumberTxPortsPerBand</i> <i>}</i> 2. <i>parameterLx</i> 3. <i>amplitudeScalingType</i> 4. <i>amplitudeSubsetRestriction</i>	<i>CodebookParameters</i>	n/a	n/a						

		<p>1) A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} across all CCs simultaneously. Note: the above list doesn't differentiate the latency class and feedback type.</p> <p>2) Parameter "Lx" (number of beams) in codebook generation, where x is index of Tx ports, corresponding to 4,8,12,16,24 and 32 ports.</p> <p>3) Support amplitude scaling type</p> <p>4) Support amplitude subset restriction level</p>		<p><i>csi-RS-IM-ReceptionForFeedbackPerBandComb</i> {</p> <p>1.2. <i>maxNumberSimultaneousNZP-CSI-RS-ActBWP-AIICC</i></p> <p>1.3. <i>totalNumberPortsSimultaneousNZP-CSI-RS-ActBWP-AIICC</i></p> <p>}</p>	<p><i>CA-ParametersNR-v1540</i></p>			<p>Simultaneously doesn't mean in the same slot</p> <p>For the purpose of component-1 calculation: CSI-RS resources and CSI-RS ports within one CSI-RS resource are counted N times if the CSI-RS resource is referred by N report settings.</p>	<p>Optional with capability signalling Component-1: Maximum size of the list is 16. The candidate values for the max # of Tx port in one resource is {4, 8, 12, 16, 24, 32} The candidate value set of the max # of resources is: {from 1 to 64} The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is: {from 2 to 256} Component-2, candidate values {2,3,4} Component-3, candidate values set: {wideband, wideband/subband} Component-4, candidate value set: {"no amplitude subset restriction", "support amplitude subset restriction"} Optional with capability signalling</p>
2-42	Support Type II SP-CSI feedback on long PUCCH	Support type II SP-CSI feedback part-1 on PUCCH formats over 4 – 14 OFDM symbols once per slot	2-41	<i>type2-SP-CSI-Feedback-LongPUCCH</i>	<i>Phy-ParametersCommon</i>	No	No		
2-43	Type II codebook with port selection	<p>1) A list of supported combinations, each combination is {Max # of Tx ports in one resource, Max # of resources and total # of Tx ports} across all CCs simultaneously. Note: the above list doesn't differentiate the latency class and feedback type.</p> <p>2) Parameter "Lx" (number of selected ports) in codebook generation, where x is index of Tx ports, corresponding to 4,8,12,16,24 and 32 ports.</p> <p>3) Support amplitude scaling type</p>		<p>1. <i>supportedCSI-RS-ResourceList SEQUENCE (SIZE (1..maxNrofCSI-RS-Resources)) OF</i> {</p> <p>1.1. <i>maxNumberTxPortsPerResource</i></p> <p>1.2. <i>maxNumberResourcesPerBand</i></p> <p>1.3. <i>totalNumberTxPortsPerBand</i></p> <p>}</p> <p>2. <i>parameterLx</i></p> <p>3. <i>amplitudeScalingType</i></p>	<i>CodebookParameters</i>	n/a	n/a	<p>Simultaneously doesn't mean in the same slot</p> <p>For the purpose of component-1 calculation: CSI-RS resources and CSI-RS ports within one CSI-RS resource are counted N times if the CSI-RS resource is referred by N report settings.</p>	

				<i>csi-RS-IM-ReceptionForFeedbackPerBandComb</i> { 1.2. <i>maxNumberSimultaneousNZP-CSI-RS-ActBWP-AIICC</i> 1.3. <i>totalNumberPortsSimultaneousNZP-CSI-RS-ActBWP-AIICC</i> }	<i>CA-ParametersNR-v1540</i>					Optional with capability signalling Component-1: Maximum size of the list is 16. the candidate values for the max # of Tx port in one resource is {4, 8, 12, 16, 24, 32} The candidate value set of the max # of resources is: {from 1 to 64} The candidate value set of total # of ports (including both channel and NZP-CSI-RS based interference measurement) is: {from 2 to 256} Component-2, candidate values set for "Lx" is {2,3,4} Component-3, candidate values set: {wideband, wideband/subband} Component-4: candidate value set is {1:8}
2-44	Basic DL PTRS	Support 1 port of DL PTRS		<i>onePortsPTRS</i> (MSB)	<i>Phy-ParametersFRX-Diff</i>	n/a	Yes			Mandatory with capability signalling for FR2 Optional with capability signalling for FR1
2-46	Downlink PTRS density recommendation	Preferred threshold sets, TS <i>i</i> for determine PTRS density, candidate value range is the same as that of downlink PTRS RRC configuration. <i>i</i> is the index of SCS, <i>i</i> =1,2,3,4 corresponding to 15,30,60,120 kHz SCS.	2-44	<i>ptrs-DensityRecommendationSetDL</i> { 1. <i>frequencyDensity1</i> 2. <i>frequencyDensity2</i> 3. <i>timeDensity1</i> 4. <i>timeDensity2</i> 5. <i>timeDensity3</i> }	<i>MIMO-ParametersPerBand</i>	n/a	n/a	For each TS <i>i</i> , it composes of two values each selected from {1..276} for frequency density, and three values each selected from {0..29} for time density		Optional with capability signalling
2-47	Basic UL PTRS	Support 1 port of UL PTRS		<i>onePortsPTRS</i> (LSB)	<i>Phy-ParametersFRX-Diff</i>	n/a	Yes			Mandatory with capability signalling for FR2 Optional with capability signalling for FR1
2-48	Uplink PTRS	Supported 2 ports of PTRS	2-47	<i>twoPortsPTRS-UL</i>	<i>MIMO-ParametersPerBand</i>	n/a	n/a			Optional with capability signalling
2-49	Uplink PTRS density recommendation	Preferred threshold sets, TS <i>i</i> , for determine PTRS density, candidate value range is the same as that of uplink PTRS RRC configuration. <i>i</i> is the index of SCS, <i>i</i> =1,2,3,4 corresponding to 15,30,60,120 kHz SCS.	2-47	<i>ptrs-DensityRecommendationSetUL</i> { 1. <i>frequencyDensity1</i> 2. <i>frequencyDensity2</i> 3. <i>timeDensity1</i> 4. <i>timeDensity2</i> 5. <i>timeDensity3</i> 6. <i>sampleDensity1</i> 7. <i>sampleDensity2</i> 8. <i>sampleDensity3</i> 9. <i>sampleDensity4</i> 10. <i>sampleDensity5</i> }	<i>MIMO-ParametersPerBand</i>	n/a	n/a	For each TS <i>i</i> , it composes of two values each selected from {1..276} for frequency density, and three values each selected from {0..29} for time density, and five values each selected from {1..276} for sample density		Optional with capability signalling

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2-50	Basic TRS	1) Support of TRS (mandatory) 2) All the periodicity are supported. 3) Support TRS bandwidth configuration as both "BWP" and "min(52, BWP)"	n/a		n/a	n/a	n/a	TRS bandwidth configuration does not imply UE processing bandwidth	Mandatory without capability signalling	
2-51	TRS (CSI-RS for tracking)	1) TRS burst length (X), 2) Max # of TRS resource sets (per CC) UE is able to track simultaneously 3) Max # of TRS resource sets configured to UE per CC 4) Max # of TRS resource sets configured to UE across CCs	2-50	<i>csi-RS-ForTracking</i> { 1. <i>maxBurstLength</i> 2. <i>maxSimultaneousResourceSetsPerCC</i> 3. <i>maxConfiguredResourceSetsPerCC</i> 4. <i>maxConfiguredResourceSetsAllCC</i> }	<i>MIMO-ParametersPerBand</i>	n/a	n/a		Mandatory with capability signalling Component-1: candidate values {1, "both 1 and 2"}. UE is mandated to report "both 1 and 2" Component-2: Candidate value set: {1 to 8} Component-3: Candidate value set: {1 to 64} UE is mandated to report at least 8 for FR1 and 16 for FR2. Component-4: Candidate value set: {1 to 256} UE is mandated to report at least 16 for FR1 and 32 for FR2. Optional with capability signalling	
2-51a	Aperiodic TRS	DCI triggering Aperiodic TRS associated with periodic TRS	2-50	<i>aperiodicTRS</i>	<i>MIMO-ParametersPerBand</i>	n/a	Yes			
2-52	Basic SRS	1) Support 1 port SRS transmission 2) Support periodic/aperiodic SRS transmission 3) Support SRS Frequency intra/inter-slot hopping within BWP 4) At least one SRS resource per CC for aperiodic and periodic separately		n/a	n/a	n/a	n/a		Mandatory without capability signalling	

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2-53	SRS resources	1) Maximum number of aperiodic SRS resources (configured to UE) per BWP 2) Maximum number of aperiodic SRS resources (configured to UE) per BWP per slot 3) Maximum number of periodic SRS resources (configured to UE) per BWP 4) Maximum number of periodic SRS resources (configured to UE) per BWP per slot 5) Maximum number of semi-persistent SRS resources (configured to UE) per BWP 6) Maximum number of semi-persistent SRS resources (configured to UE) per BWP per slot 7) Maximum number of SRS port per resource	2-52	<i>supportedSRS-Resources</i> { 1. <i>maxNumberAperiodicSRS-PerBWP</i> 2. <i>maxNumberAperiodicSRS-PerBWP-PerSlot</i> 3. <i>maxNumberPeriodicSRS-PerBWP</i> 4. <i>maxNumberPeriodicSRS-PerBWP-PerSlot</i> 5. <i>maxNumberSemiPersitentSRS-PerBWP</i> 6. <i>maxNumberSP-SRS-PerBWP-PerSlot</i> 7. <i>maxNumberSRS-Ports-PerResource</i> }	<i>FeatureSetUplink</i>	n/a	n/a			Mandatory with capability signalling Component-1: candidate value: {from 1, 2, 4, 8, 16} Component-2 candidate value: {1,2,3,4,5,6} Component-3: candidate value: {from 1, 2, 4, 8, 16} Component-4 candidate value: {1,2,3,4,5, 6} Component-5: candidate value: {from 1, 2, 4, 8, 16} } Component-6 candidate value: {1, 2,3,4,5, 6} Component-7 candidate values: {1, 2, 4}
2-55	SRS Tx switch	1) Support SRS Tx port switch, 2) Report whether the uplink TX switching impact to downlink receiving in a band, 3) Report whether the UL Tx is switched together with UL Tx in another band	2-53	<i>srs-TxSwitch</i> { 1. <i>supportedSRS-TxPortSwitch</i> 2. <i>txSwitchImpactToRx</i> 3. <i>txSwitchWithAnotherBand</i> }	<i>BandParameters-v1540</i>	n/a	n/a	Component-2 is per band pair per band combination Component-3 is per band pair per band combination The band pair in Component-2 and Component-3 can be an LTE band and an NR band 2T4R is 2 pairs of antennas "R" refers to a subset/set of receive antennas for PDSCH; "T" refers to the SRS antennas used for DL CSI acquisition RAN4 reply LS, R1-1805817, includes candidate value sets	Support SP-SRS is mandatory with capability Mandatory with capability signalling Component-1 is a list of TRx pairs, candidates are {"Not supported", "1T2R", "1T4R", "2T4R", "1T4R/2T4R", "1T=1R", "2T=2R", "4T=4R"} Component-2: Candidate value set: {yes, no} Component-3: Candidate value set: {yes, no}	
2-56	SRS carrier switch	Report inter-cell switching time capability	2-53	<i>srs-CarrierSwitch</i> { <i>srs-SwitchingTimesListNR</i> , or <i>srs-SwitchingTimesListEUTRA</i> }	<i>BandParameters-v1540</i>	No	n/a			Optional with capability signalling
2-58	For SRS for CB PUSCH and antenna switching on FR1, zero slot offset for aperiodic SRS transmission	For SRS for CB PUSCH and antenna switching on FR1, support of zero slot offset between aperiodic SRS triggering and transmission	2-53	<i>zeroSlotOffsetAperiodicSRS</i>	<i>FeatureSetUplink-v1540</i>	n/a	n/a			Optional with capability signalling
2-59	Configured spatial relations	Maximum number of configured spatial relations per CC for PUCCH and SRS			MIMO-ParametersPerBand	n/a	Only applicable to FR2			Candidate value set: {4, 8, 16, 32, 64, 96} UE is mandated to report 16 or higher values.

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2-60	Active spatial relations	Maximum total number of {unique DL RS (except for aperiodic NZP CSI-RS) and SRS without spatial relation configured, and, TCI states available for DCI triggering of aperiodic NZP CSI-RS}, for indicating spatial domain transmit filter for PUCCH and SRS for PUSCH, per BWP per CC	2-59	<i>spatialRelations</i> { 2-59. <i>maxNumberConfiguredSpatialRelations</i> 2-60. <i>maxNumberActiveSpatialRelations</i> 2-61. <i>additionalActiveSpatialRelationPUCCH</i> 2-62. <i>maxNumberDL-RS-QCL-TypeD</i> }	n/a	Only applicable to FR2	"Unique" means RS identity. An SSB and a CSI-RS are always counted as different. Two CSI-RSs are different if they have different CSI-RS resource IDs.	Mandatory with capability signalling Candidate value set: {1, 2, 4, 8, 14}	
2-61	Additional active spatial relation for PUCCH	Support one additional active spatial relation for PUCCH	2-60		n/a	n/a	Only applicable if 2-60 is set to 1.	Mandatory with capability signalling	
2-62	Max number of downlink RS resources used for QCL type-D in the active TCI states and active spatial relation info	Max number of downlink RS resources in the active TCI states and active spatial relation info per CC	2-4, 2-4a and 2-60		n/a	n/a	Reference relationship follows 2-4/2-60	Optional with capability signalling Candidate value set: {1,2,4,8, 14}	

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3. DL control channel and procedure	3-1	Basic DL control channel	<p>1) One configured CORESET per BWP per cell in addition to CORESET0</p> <ul style="list-style-type: none"> - CORESET resource allocation of 6RB bit-map and duration of 1 – 3 OFDM symbols for FR1 - For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSSs, CORESET resource allocation of 6RB bit-map and duration 1-3 OFDM symbols for FR2 - For type 1 CSS with dedicated RRC configuration and for type 3 CSS, UE specific SS, CORESET resource allocation of 6RB bit-map and duration 1-2 OFDM symbols for FR2 - REG-bundle sizes of 2/3 RBs or 6 RBs - Interleaved and non-interleaved CCE-to-REG mapping - Precoder-granularity of REG-bundle size - PDCCH DMRS scrambling determination - TCI state(s) for a CORESET configuration <p>2) CSS and UE-SS configurations for unicast PDCCH transmission per BWP per cell</p> <ul style="list-style-type: none"> - PDCCH aggregation levels 1, 2, 4, 8, 16 - UP to 3 search space sets in a slot for a scheduled SCell per BWP <p>This search space limit is before applying all dropping rules.</p> <ul style="list-style-type: none"> - For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, the monitoring occasion is within the first 3 OFDM symbols of a slot - For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, the monitoring occasion can be any OFDM symbol(s) of a slot, with the monitoring occasions for any of Type 1-CSS without dedicated RRC configuration, or Types 0, 0A, or 2 CSS configurations within a single span of three consecutive OFDM symbols within a slot <p>3) Monitoring DCI formats 0_0, 1_0, 0_1, 1_1</p> <p>4) Number of PDCCH blind decodes per slot with a</p>	n/a	n/a	n/a	n/a	Mandatory without capability signalling

		given SCS follows Case 1-1 table 5) Processing one unicast DCI scheduling DL and one unicast DCI scheduling UL per slot per scheduled CC for FDD 6) Processing one unicast DCI scheduling DL and 2 unicast DCI scheduling UL per slot per scheduled CC for TDD						
3-1'	For type 1 CSS with dedicated RRC configuration and for type 3 CSS, UE specific SS, CORESET resource allocation of 6RB bit-map and duration 3 OFDM symbols for FR2	For type 1 CSS with dedicated RRC configuration and for type 3 CSS, UE specific SS, CORESET resource allocation of 6RB bit-map and duration 3 OFDM symbols for FR2	<i>type1-3-CSS</i>	<i>FeatureSetDownlink</i>	n/a	n/a		Mandatory with capability signalling
3-2	PDCCH monitoring on any span of up to 3 consecutive OFDM symbols of a slot	For a given UE, all search space configurations are within the same span of 3 consecutive OFDM symbols in the slot	<i>pdccchMonitoringSingleOccasion</i>	<i>Phy-ParametersFR1</i>	No	Applicable only to FR1		Optional with capability signalling
3-3	More than one CORESET configurations per BWP in addition to CORESET0	More than one CORESET configurations per BWP in addition to CORESET0	<i>multipleCORESET</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling for FR1 Mandatory with capability signalling for FR2
3-4	More than one TCI state configurations per CORESET	More than one TCI state configurations per CORESET	<i>multipleTCI</i>	<i>BandNR</i>	n/a	n/a	UE is only required to track one active TCI state per CORESET UE is required to support minimum between 64 and number of configured TCI states in 2-4, component 2).	Mandatory with capability signaling which shall be set to '1'
3-5	For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, monitoring occasion can be any OFDM symbol(s) of a slot for Case 2	For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, monitoring occasion can be any OFDM symbol(s) of a slot for Case 2	<i>pdccch-MonitoringAnyOccasions {</i> <i>3-5. withoutDCI-Gap</i> <i>3-5a. withDCI-Gap</i> <i>}</i>	<i>FeatureSetDownlink</i>	n/a	n/a		Optional with capability signalling

3-5a	<p>For type 1 CSS with dedicated RRC configuration, type 3 CSS, and UE-SS, monitoring occasion can be any OFDM symbol(s) of a slot for Case 2 with a DCI gap</p>	<p>For type 1 CSS with dedicated RRC configuration, type 3 CSS and UE-SS, monitoring occasion can be any OFDM symbol(s) of a slot for Case 2, with minimum time separation (including the cross-slot boundary case) between two DL unicast DCIs, between two UL unicast DCIs, or between a DL and an UL unicast DCI in different monitoring occasions where at least one of them is not the monitoring occasions of FG-3-1, for a same UE as</p> <ul style="list-style-type: none">- 2OFDM symbols for 15kHz- 4OFDM symbols for 30kHz- 7OFDM symbols for 60kHz with NCP- 11OFDM symbols for 120kHz <p>Up to one unicast DL DCI and up to one unicast UL DCI in a monitoring occasion except for the monitoring occasions of FG 3-1.</p> <p>In addition for TDD the minimum separation between the first two UL unicast DCIs within the first 3 OFDM symbols of a slot can be zero OFDM symbols.</p>	n/a	n/a	Optional with capability signalling
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3-5b	All PDCCH monitoring occasion can be any OFDM symbol(s) of a slot for Case 2 with a span gap	<p>PDCCH monitoring occasions of FG-3-1, plus additional PDCCH monitoring occasion(s) can be any OFDM symbol(s) of a slot for Case 2, and for any two PDCCH monitoring occasions belonging to different spans, where at least one of them is not the monitoring occasions of FG-3-1, in same or different search spaces, there is a minimum time separation of X OFDM symbols (including the cross-slot boundary case) between the start of two spans, where each span is of length up to Y consecutive OFDM symbols of a slot. Spans do not overlap. Every span is contained in a single slot. The same span pattern repeats in every slot. The separation between consecutive spans within and across slots may be unequal but the same (X, Y) limit must be satisfied by all spans. Every monitoring occasion is fully contained in one span. In order to determine a suitable span pattern, first a bitmap b(l), 0<=l<=13 is generated, where b(l)=1 if symbol l of any slot is part of a monitoring occasion, b(l)=0 otherwise. The first span in the span pattern begins at the smallest l for which b(l)=1. The next span in the span pattern begins at the smallest l not included in the previous span(s) for which b(l)=1. The span duration is max{maximum value of all CORESET durations, minimum value of Y in the UE reported candidate value} except possibly the last span in a slot which can be of shorter duration. A particular PDCCH monitoring configuration meets the UE capability limitation if the span arrangement satisfies the gap separation for at least one (X, Y) in the UE reported candidate value set in every slot, including cross slot boundary.</p> <p>For the set of monitoring occasions which are within the same span:</p> <ul style="list-style-type: none"> Processing one unicast DCI scheduling DL and one unicast DCI scheduling UL 	<p><i>pdccch-MonitoringAnyOccasionsWithSpanGap</i></p> <p>(X, Y): <i>set1</i> = (7, 3); <i>set2</i> = (4, 3) and (7, 3); <i>set3</i> = (2, 2) and (4, 3) and (7, 3).</p>	<i>FeatureSetDownlink-v1540</i>	n/a	n/a	This capability is necessary for each SCS.	<p>Optional with capability signalling</p> <p>Candidate value set for (X, Y): {(7, 3), (4, 3) and (7, 3), (2, 2) and (4, 3) and (7, 3)}</p>

		<p>per scheduled CC across this set of monitoring occasions for FDD</p> <ul style="list-style-type: none">Processing one unicast DCI scheduling DL and two unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for TDDProcessing two unicast DCI scheduling DL and one unicast DCI scheduling UL per scheduled CC across this set of monitoring occasions for TDD <p>The number of different start symbol indices of spans for all PDCCH monitoring occasions per slot, including PDCCH monitoring occasions of FG-3-1, is no more than floor(14/X) (X is minimum among values reported by UE).</p> <p>The number of different start symbol indices of PDCCH monitoring occasions per slot including PDCCH monitoring occasions of FG-3-1, is no more than 7.</p> <p>The number of different start symbol indices of PDCCH monitoring occasions per half-slot including PDCCH monitoring occasions of FG-3-1 is no more than 4 in SCell.</p>					
3-6	Dynamic SFI monitoring	Adjust periodic and semi-persistent signal reception and transmission in response to detected dynamic UL/DL configuration	<i>dynamicSFI</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes	Optional with capability signalling
3-7	Precoder-granularity of CORESET size	Precoder-granularity of CORESET size	<i>precoderGranularityCORESET</i>	<i>Phy-ParametersCommon</i>	No	No	Optional with capability signalling
3-8	Up to 10 search spaces in a SCell	Up to 10 search spaces in a slot in an SCell per BWP	<i>maxNumberSearchSpaces</i>	<i>Phy-ParametersCommon</i>	No	No	Optional with capability signalling

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4. UL control channel and procedure	4-1	Basic UL control channel	1) PUCCH format 0 over 1 OFDM symbols once per slot 2) PUCCH format 0 over 2 OFDM symbols once per slot with frequency hopping as "enabled" 3) PUCCH format 1 over 4 – 14 OFDM symbols once per slot with intra-slot frequency hopping as "enabled" 5) One SR configuration per PUCCH group 6) HARQ-ACK transmission once per slot with its resource/timing determined by using the DCI 7) SR/HARQ multiplexing once per slot using a PUCCH when SR/HARQ-ACK are supposed to be sent by overlapping PUCCH resources with the same starting symbols in a slot 8) HARQ-ACK piggyback on PUSCH with/without aperiodic CSI once per slot when the starting OFDM symbol of the PUSCH is the same as the starting OFDM symbols of the PUCCH resource that HARQ-ACK would have been transmitted on 9) Semi-static beta-offset configuration for HARQ-ACK 10) Single group of overlapping PUCCH/PUCCH and overlapping PUCCH/PUSCH s per slot per PUCCH cell group for control multiplexing	n/a	n/a	n/a	n/a	Mandatory without capability signalling
	4-2	2 PUCCH of format 0 or 2 in consecutive symbols	1) 2 PUCCH format 0/2 in different symbols and once per slot for HARQ-ACK, 2) 2 PUCCH format 0 in different symbols and once per slot for SR 3) 2 PUCCH format 2 in different symbols and once per slot for CSI over two consecutive OFDM symbols	<i>twoPUCCH-F0-2-ConsecSymbols</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes	Optional with capability signalling
	4-3	PUCCH format 2 over 1 – 2 OFDM symbols once per slot with frequency hopping as "enabled"	PUCCH format 2 over 1 – 2 OFDM symbols once per slot with frequency hopping as "enabled"	<i>pucch-F2-WithFH</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	Mandatory with capability signalling which shall be set to '1'
	4-4	PUCCH format 3 over 4 – 14 OFDM symbols once per slot with frequency hopping as "enabled"	PUCCH format 3 over 4 – 14 OFDM symbols once per slot with frequency hopping as "enabled"	<i>pucch-F3-WithFH</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	Mandatory with capability signalling which shall be set to '1'
	4-5	PUCCH format 4 over 4 – 14 OFDM symbols once per slot with frequency hopping as "enabled"	PUCCH format 4 over 4 – 14 OFDM symbols once per slot with frequency hopping as "enabled"	<i>pucch-F4-WithFH</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	Mandatory with capability signalling

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4-6	Non-frequency hopping for PUCCH formats 0 and 2 with frequency hopping as "disabled"	Non-frequency hopping for PUCCH formats 0 and 2 with frequency hopping as "disabled"		<i>freqHoppingPUCCH-F0-2</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	The value indicated by this field is "notSupported".	Mandatory with capability signalling
4-7	Non-frequency hopping for PUCCH format 1, 3, and 4 with frequency hopping as "disabled"	Non-frequency hopping for PUCCH format 1, 3, and 4 with frequency hopping as "disabled"		<i>freqHoppingPUCCH-F1-3-4</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	The value indicated by this field is "notSupported".	Mandatory with capability signalling
4-10	Dynamic HARQ-ACK codebook	Dynamic HARQ-ACK codebook		<i>dynamicHARQ-ACK-Codebook</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signaling which shall be set to '1'
4-11	Semi-static HARQ-ACK codebook	Semi-static HARQ-ACK codebook		<i>semiStaticHARQ-ACK-Codebook</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
4-12	HARQ-ACK spatial bundling for PUCCH or PUSCH per PUCCH group	HARQ-ACK spatial bundling for PUCCH or PUSCH per PUCCH group		<i>spatialBundlingHARQ-ACK</i>	<i>Phy-ParametersCommon</i>	No	No	Applicable to UE supporting more than 4 layers	Mandatory with capability signalling
4-13	More than one SR configurations per PUCCH group	More than one SR configurations per PUCCH group		<i>multipleSR-Configurations</i>	<i>MAC-ParametersXDD-Diff</i>	Yes	No		Optional with capability signalling
4-19	SR/HARQ-ACK/CSI multiplexing once per slot using a PUCCH (or HARQ-ACK/CSI piggybacked on a PUSCH) when SR/HARQ-ACK/CSI are supposed to be sent with the same starting symbol on the PUCCH resources in a slot	SR/HARQ-ACK/CSI multiplexing once per slot, where overlapping PUCCH resources have the same starting symbols on the PUCCH resources in a slot while precluding the case of SR/HARQ-ACK by overlapping PUCCH resources with the same starting symbols on the PUCCH resources in a slot		<i>sameSymbol in mux-SR-HARQ-ACK-CSI-PUCCH-OncePerSlot</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	If FG4-28 is not included or not supported, HARQ-ACK/CSI piggyback on PUSCH once per slot when the starting OFDM symbol of the PUSCH is the same as the starting OFDM symbols of the PUCCH resource(s) that would have been transmitted on	Mandatory with capability signalling
								If FG4-28 is included and supported, HARQ-ACK/CSI piggyback on PUSCH once per slot for which case the starting OFDM symbol of the PUSCH is the different from the starting OFDM symbols of the PUCCH resource(s) that would have been transmitted on	
4-19a	SR/HARQ-ACK multiplexing once per slot using a PUCCH (or HARQ-ACK piggybacked on a PUSCH) when SR/HARQ-ACK are supposed to be sent with different starting symbols in a slot	Overlapping PUCCH resources have different starting symbols in a slot	4-19	<i>mux-SR-HARQ-ACK-PUCCH</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling

4-19b	SR/HARQ-ACK/CSI multiplexing more than once per slot using a PUCCH (or HARQ-ACK/CSI piggybacked on a PUSCH) when SR/HARQ-ACK/CSI are supposed to be sent with the same or different starting symbol in a slot	Overlapping PUCCH resources have same or different starting symbols in a slot	4-19c	<i>mux-SR-HARQ-ACK-CSI-PUCCH-MultiPerSlot</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
4-19c	SR/HARQ-ACK/CSI multiplexing once per slot using a PUCCH (or HARQ-ACK/CSI piggybacked on a PUSCH) when SR/HARQ-ACK/CSI are supposed to be sent with different starting symbols in a slot	Overlapping PUCCH resources have different starting symbols in a slot	4-19a	<i>diffSymbol</i> in <i>mux-SR-HARQ-ACK-CSI-PUCCH-OncePerSlot</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
4-20	UCI code-block segmentation	UCI code-block segmentation		<i>uci-CodeBlockSegmentation</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Mandatory with capability signalling
4-21	Dynamic beta-offset configuration and indication for HARQ-ACK and/or CSI	Dynamic beta-offset configuration and indication for HARQ-ACK and/or CSI		<i>dynamicBetaOffsetInd-HARQ-ACK-CSI</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
4-22	1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3, or 4 in the same slot	1 PUCCH format 0 or 2 and 1 PUCCH format 1, 3, and 4 in the same slot		<i>onePUCCH-LongAndShortFormat</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
4-22a	2 PUCCH transmissions in the same slot which are not covered by 4-22 and 4-2	2 PUCCH transmissions in the same slot which are not covered by 4-22 and 4-2		<i>twoPUCCH-AnyOthersInSlot</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
4-23	Repetitions for PUCCH format 1, 3, and 4 over multiple slots with K = 2, 4, 8	Repetitions for PUCCH format 1, 3, and 4 over multiple slots with K = 2, 4, 8		<i>pucch-Repetition-F1-3-4</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
4-24	PUCCH-spatialrelationinfo indication by a MAC CE per PUCCH resource	PUCCH-spatialrelationinfo indication by a MAC CE per PUCCH resource		<i>pucch-SpatialRelInfoMAC-CE</i>	<i>BandNR</i>	n/a	n/a		Mandatory with capability signalling for FR2 Optional with capability signalling for FR1
4-25	Parallel SRS and PUCCH/PUSCH transmission across CCs in inter-band CA	Parallel SRS and PUCCH/PUSCH transmission across CCs in inter-band CA	2-52, 4-1, 2-12, 6-6	<i>parallelTxSRS-PUCCH-PUSCH</i>	<i>CA-ParametersNR</i>	n/a	n/a	This feature is supported only in inter-band CA.	Optional with capability signalling
4-26	Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA	Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA	1-1, 2-52, 4-1, 2-12, 6-6	<i>parallelTxPRACH-SRS-PUCCH-PUSCH</i>	<i>CA-ParametersNR</i>	n/a	n/a	This feature is supported only in inter-band CA.	Optional with capability signalling
4-27	More than one group of overlapping channels for control multiplexing	More than one group of overlapping PUCCHs and PUSCHs per slot per PUCCH cell group for control multiplexing		<i>mux-MultipleGroupCtrlCH-Overlap</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	If a UE does not indicate supporting any of 4-2, 4-22, and 4-22a, the UE is not expected to be scheduled with more than one group of overlapping PUCCHs without PUSCH in each of the groups	Optional with capability signalling

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4-28	HARQ-ACK multiplexing on PUSCH with different PUCCH/PUSCH starting OFDM symbols	HARQ-ACK piggyback on a PUSCH with/without aperiodic CSI once per slot when the starting OFDM symbol of the PUSCH is different from the starting OFDM symbols of the PUCCH resource that HARQ-ACK would have been transmitted on	4-1	<i>mux-HARQ-ACK-PUSCH-DiffSymbol</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	Mandatory with capability signalling	

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5. Scheduling/HARQ operation	5-1	Basic scheduling/HARQ operation	<p>1) Frequency-domain resource allocation</p> <ul style="list-style-type: none"> - RA Type 0 only and Type 1 only for PDSCH without interleaving - RA Type 1 for PUSCH without interleaving <p>2) Time-domain resource allocation</p> <ul style="list-style-type: none"> - 1-14 OFDM symbols for PUSCH once per slot - One unicast PDSCH per slot - Starting symbol, and duration are determined by using the DCI - PDSCH mapping type A with 7-14 OFDM symbols - PUSCH mapping type A and type B - For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, PDSCH mapping type A with {4-14} OFDM symbols and type B with {2, 4, 7} OFDM symbols <p>3) TBS determination</p> <p>4) Nominal UE processing time for N1 and N2 (Capability #1)</p> <p>5) HARQ process operation with configurable number of DL HARQ processes of up to 16</p> <p>6) Cell specific RRC configured UL/DL assignment for TDD</p> <p>7) Dynamic UL/DL determination based on L1 scheduling DCI with/without cell specific RRC configured UL/DL assignment</p> <p>8) Intra-slot frequency-hopping for PUSCH scheduled by Type 1 CSS before RRC connection</p> <p>9) In TDD support at most one switch point per slot for actual DL/UL transmission(s)</p> <p>10) DL scheduling slot offset $K_0=0$</p> <p>11) DL scheduling slot offset $K_0=1$ for type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS</p> <p>12) UL scheduling slot offset $K_2 \leq 12$</p> <p>For type 1 CSS without dedicated RRC configuration and for type 0, 0A, and 2 CSS, interleaving for VRB-to-PRB mapping for PDSCH</p>	n/a	n/a	n/a	n/a	Mandatory without capability signalling

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	5-1a	UE specific RRC configure UL/DL assignment	Dynamic UL/DL determination based on L1 scheduling DCI with cell-specific and UE specific RRC configured UL/DL assignment	<i>ue-SpecificUL-DL-Assignment</i>	<i>FeatureSetDownlink</i>	n/a	n/a		Optional with capability signalling
	5-1b	More than one DL/UL switch point in a slot	In TDD support more than one switch points in a slot for actual DL/UL transmission(s)	<i>tdd-MultiDL-UL-SwitchPerSlot</i>	<i>Phy-ParametersFRX-Diff</i>	TDD only	Yes		Optional with capability signalling
	5-2	RA Type 0 for PUSCH	RA Type 0 for PUSCH	<i>ra-Type0-PUSCH</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
	5-3	Dynamic switching between RA Type 0 and RA Type 1 for PDSCH	Dynamic switching between RA Type 0 and RA Type 1 for PDSCH	<i>dynamicSwitchRA-Type0-1-PDSCH</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
	5-4	Dynamic switching between RA Type 0 and RA Type 1 for PUSCH	Dynamic switching between RA Type 0 and RA Type 1 for PUSCH	<i>dynamicSwitchRA-Type0-1-PUSCH</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
	5-5a	UE PDSCH processing capability #2	UE can report values 'X' and 'Fallback', and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology <ul style="list-style-type: none"> - When configured with less than or equal to X DL CCs, the UE may expect to be scheduled with up to 1 PDSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled, otherwise <ul style="list-style-type: none"> - If Fallback = 'SC', UE supports Capability #2 processing time on lowest cell index among the configured carriers in the band where the value is reported - If Fallback = 'Cap1-only', UE supports only Capability #1, in the band where the value is reported 2) No scheduling limitation 3) N1 based on Table 5.3-2 of TS 38.214 for given SCS from {15, 30, 60} kHz 	<i>pdsch-ProcessingType2</i>	<i>FeatureSetDownlink-v1540</i>	n/a	Applicable to FR1 only	This capability is necessary for each SCS (15kHz, 30kHz, 60kHz) More than one set of per SCS per band reports can be signaled for a given band combination	Optional with capability signaling Candidate values for Component 1: X in {1, ..., 16}, Fallback {'SC','Cap1-only'}
	5-5b	UE PDSCH processing capability #2 with scheduling limitation for 30kHz-SCS	Capability #2 supported only if 1 carrier configured in the band (independent of #carriers configured in other bands) 2) Max PDSCH BW of 136 PRBs on the configured serving cell which processingType2Enabled is configured and set to enabled 3) N1 based on Table 5.3-2 of TS 38.214 for 30 kHz SCS 4) UE reports the number of unicast PDSCH per slot for different TBs	<i>pdsch-ProcessingType2-Limited</i>	<i>FeatureSetDownlink-v1540</i>	n/a	Applicable to FR1 only	This capability is applicable to 30kHz-SCS only	Optional with capability signaling Component 4) the value ranges {1, 2, 4, 7}

5-5c	UE PUSCH processing capability #2	UE can report values 'X' and 'Fallback', and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology - When configured with less than or equal to X UL CCs, the UE may expect to be scheduled with up to 1 PUSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled, otherwise - If Fallback = 'SC', UE supports Capability #2 processing time on lowest cell index among the configured carriers in the band where the value is reported - If Fallback = 'Cap1-only', UE supports only Capability #1, in the band where the value is reported 2) N2 based on Table 6.4-2 of TS 38.214 for given SCS from {15, 30, 60} kHz	<i>pusch-ProcessingType2</i>	<i>FeatureSetUplink-v1540</i>	n/a	Applicable to FR1 only	This capability is necessary for each SCS (15kHz, 30kHz, 60kHz) More than one set of per SCS per band reports can be signaled for a given band combination	Optional with capability signaling Candidate values for Component 1: X in {1, ..., 16}, Fallback {'SC', 'Cap1-only'}
5-6	PDSCH mapping type A with less than 7 OFDM symbols	or type 1 CSS with dedicated RRC configuration, for type 3 CSS and UE-SS, PDSCH mapping type A with less than 7 OFDM symbols	<i>pdsch-MappingTypeA</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling which shall be set to '1'
5-6a	PDSCH mapping type B	PDSCH mapping type B	<i>pdsch-MappingTypeB</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
5-7	Interleaving for VRB-to-PRB mapping for PDSCH	Interleaving for VRB-to-PRB mapping for PDSCH	<i>interleavingVRB-ToPRB-PDSCH</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
5-9	Intra-slot frequency-hopping for PUSCH except for PUSCH scheduled by Type 1 CSS before RRC connection	Intra-slot frequency-hopping for PUSCH except for PUSCH scheduled by Type 1 CSS before RRC connection	<i>intraSlotFreqHopping-PUSCH</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Mandatory with capability signalling
5-10	Inter-slot frequency hopping for PUSCH	Inter-slot frequency hopping for PUSCH	<i>interSlotFreqHopping-PUSCH</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-11	Up to 2 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 1	Up to 2 unicast PDSCHs per slot per CC only in TDM is supported for Capability 1 1) PDSCH(s) for Msg. 4 is included	<i>pdsch-ProcessingType1-DifferentTB-PerSlot</i>	<i>FeatureSetDownlink</i>	n/a	n/a	This capability is necessary for each SCS.	Optional with capability signalling
5-11a	Up to 7 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 1	Up to 7 unicast PDSCHs per slot per CC only in TDM is supported for Capability 1 1) PDSCH(s) for Msg. 4 is included			n/a	n/a	This capability is necessary for each SCS.	Optional with capability signalling
5-11b	Up to 4 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 1	Up to 4 unicast PDSCHs per slot per CC only in TDM is supported for Capability 1 1) PDSCH(s) for Msg. 4 is included			n/a	n/a	This capability is necessary for each SCS.	Optional with capability signalling

5-12	Up to 2 PUSCHs per slot per CC for different TBs for UE processing time Capability 1	Up to 2 unicast PUSCHs per slot per CC only in TDM is supported for Capability 1		<i>pusch-ProcessingType1-DifferentTB-PerSlot</i>	<i>FeatureSetUplink</i>	n/a	n/a	This capability is necessary for each SCS.	Optional with capability signalling
5-12a	Up to 7 PUSCHs per slot per CC for different TBs for UE processing time Capability 1	Up to 7 unicast PUSCHs per slot per CC only in TDM is supported for Capability 1				n/a	n/a	This capability is necessary for each SCS.	Optional with capability signalling
5-12b	Up to 4 PUSCHs per slot per CC for different TBs for UE processing time Capability 1	Up to 4 unicast PUSCHs per slot per CC only in TDM is supported for Capability 1				n/a	n/a	This capability is necessary for each SCS.	Optional with capability signalling
5-13	Up to 2 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 2	Up to 2 unicast PDSCHs per slot per CC only in TDM is supported for Capability 2 UE can report values 'X' and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology - When configured with less than or equal to X DL CCs, the UE may expect to be scheduled with up to 2 PDSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled 2) No scheduling limitation 3) N1 based on Table 5.3-2 of TS 38.214 for given SCS from {15, 30, 60} kHz	5-5a	<i>pdsch-ProcessingType2</i>	<i>FeatureSetDownlink</i>	n/a	n/a	This capability is necessary for each SCS More than one set of per SCS per band reports can be signalled for a given band combination	Optional with capability signalling Candidate values for Component 1: X in {1, ..., 16},
5-13a	Up to 7 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 2	Up to 7 unicast PDSCHs per slot per CC only in TDM is supported for Capability 2 UE can report values 'X' and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology - When configured with less than or equal to X DL CCs, the UE may expect to be scheduled with up to 7 PDSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled 2) No scheduling limitation 3) N1 based on Table 5.3-2 of TS 38.214 for given SCS from {15, 30, 60} kHz	5-5a			n/a	n//a	This capability is necessary for each SCS More than one set of per SCS per band reports can be signalled for a given band combination	Optional with capability signalling Candidate values for Component 1: X in {1, ..., 16},

5-13c	Up to 4 unicast PDSCHs per slot per CC for different TBs for UE processing time Capability 2	<p>Up to 4 unicast PDSCHs per slot per CC only in TDM is supported for Capability 2</p> <p>UE can report values 'X' and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology</p> <ul style="list-style-type: none">- When configured with less than or equal to X DL CCs, the UE may expect to be scheduled with up to 4 PDSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled <p>2) No scheduling limitation</p> <p>3) N1 based on Table 5.3-2 of TS 38.214 for given SCS from {15, 30, 60} kHz</p>	5-5a			n/a	n/a	<p>This capability is necessary for each SCS</p> <p>More than one set of per SCS per band reports can be signalled for a given band combination</p>	<p>Optional with capability signalling</p> <p>Candidate values for Component 1: X in {1, ..., 16},</p>
5-13d	Up to 2 PUSCHs per slot per CC for different TBs for UE processing time Capability 2	<p>Up to 2 unicast PUSCHs per slot per CC only in TDM is supported for Capability 2</p> <p>UE can report values 'X' and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology</p> <ul style="list-style-type: none">- When configured with less than or equal to X UL CCs, the UE may expect to be scheduled with up to 2 PUSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled <p>2) N2 based on Table 6.4-2 of TS 38.214 for given SCS from {15, 30, 60} kHz</p>	5-5c	<i>pusch-ProcessingType2</i>	<i>FeatureSetUplink</i>	n/a	n/a	<p>This capability is necessary for each SCS</p> <p>More than one set of per SCS per band reports can be signalled for a given band combination</p>	<p>Optional with capability signalling</p> <p>Candidate values for Component 1: X in {1, ..., 16},</p>

5-13e	Up to 7 PUSCHs per slot per CC for different TBs for UE processing time Capability 2	Up to 7 unicast PUSCHs per slot per CC only in TDM is supported for Capability 2 UE can report values 'X' and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology - When configured with less than or equal to X UL CCs, the UE may expect to be scheduled with up to 7 PUSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled 2) N2 based on Table 6.4-2 of TS 38.214 for given SCS from {15, 30, 60} kHz	5-5c		n/a	n/a	This capability is necessary for each SCS More than one set of per SCS per band reports can be signalled for a given band combination	Optional with capability signalling Candidate values for Component 1: X in {1, ..., 16},
5-13f	Up to 4 PUSCHs per slot per CC for different TBs for UE processing time Capability 2	Up to 4 unicast PUSCHs per slot per CC only in TDM is supported for Capability 2 UE can report values 'X' and supports the following operation, only when all carriers are self-scheduled and all Capability #2 carriers in a band are of the same numerology - When configured with less than or equal to X UL CCs, the UE may expect to be scheduled with up to 4 PUSCHs per slot with Capability #2 on all of the configured serving cells for which processingType2Enabled is configured and set to enabled 2) N2 based on Table 6.4-2 of TS 38.214 for given SCS from {15, 30, 60} kHz	5-5c		n/a	n/a	This capability is necessary for each SCS More than one set of per SCS per band reports can be signalled for a given band combination	Optional with capability signalling Candidate values for Component 1: X in {1, ..., 16},
5-14	Type 1 configured PUSCH repetitions over multiple slots	K = 2, 4, 8 times repetitions with RV sequences	<i>type1-PUSCH-RepetitionMultiSlots</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-16	Type 2 configured PUSCH repetitions over multiple slots	K = 2, 4, 8 times repetitions with RV sequences	<i>type2-PUSCH-RepetitionMultiSlots</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-17	PUSCH repetitions over multiple slots	K = 2, 4, 8 times repetitions	<i>pusch-RepetitionMultiSlots</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
5-17a	PDSCH repetitions over multiple slots	K = 2, 4, 8 times repetitions	<i>pdsch-RepetitionMultiSlots</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-18	DL SPS	DL SPS	<i>downlinkSPS</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-19	Type 1 Configured UL grant	K = 1	<i>configuredUL-GrantType1</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-20	Type 2 Configured UL grant	K = 1	<i>configuredUL-GrantType2</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-21	Pre-emption indication for DL	Pre-emption indication for DL	<i>pre-EmptIndication-DL</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling

5-22	CBG-based re-transmission for DL using CBGTI	CBG-based re-transmission for DL using CBGTI		<i>cbg-TransIndication-DL</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-23	CBGFI for CBG-based re-transmission for DL	CBGFI for CBG-based re-transmission for DL	5-22	<i>cbg-FlushIndication-DL</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-24	Dynamic HARQ-ACK codebook using sub-codebooks for CBG-based re-transmission for DL	Dynamic HARQ-ACK codebook using sub-codebooks for CBG-based re-transmission for DL		<i>dynamicHARQ-ACK-CodeB-CBG-Retx-DL</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-25	CBG-based re-transmission for UL using CBGTI	CBG-based re-transmission for UL using CBGTI		<i>cbg-TransIndication-UL</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-26	Semi-static rate-matching resource set configuration for DL	1) Bitmap 1/2/3 2) controlResourceSet		<i>rateMatchingResrcSetSemi-Static</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
5-27	Dynamic rate-matching resource set configuration for DL	Bitmap 1/2/3		<i>rateMatchingResrcSetDynamic</i>	<i>Phy-ParametersCommon</i>	No	No		Optional with capability signalling
5-27a	Dynamic rate-matching control resource set for DL	Dynamic rate-matching control resource set for DL		<i>rateMatchingCtrlResrcSetDynamic</i>	<i>Phy-ParametersCommon</i>	No	No		Mandatory with capability signalling
5-28	Rate-matching around LTE CRS	Rate-matching around LTE CRS		<i>rateMatchingLTE-CRS</i>	<i>BandNR</i>	n/a	n/a		Mandatory with capability signalling
5-29	LBRM for PUSCH	Limited buffer rate matching in UL		<i>pusch-LBRM</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
5-30	DL scheduling slot offset greater than zero for PDSCH mapping type A	Support of DL scheduling slot offset (K0) greater than zero for PDSCH mapping type A		<i>dl-SchedulingOffset-PDSCH-TypeA</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes		Mandatory with capability signalling
5-30a	DL scheduling slot offset greater than zero for PDSCH mapping type B	Support of DL scheduling slot offset (K0) greater than zero for PDSCH mapping type B		<i>dl-SchedulingOffset-PDSCH-TypeB</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes		Mandatory with capability signalling
5-31	UL scheduling slot offset greater than 12	Support of UL scheduling slot offset (K2) greater than 12		<i>ul-SchedulingOffset</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes		Mandatory with capability signalling
5-32	Separation of two unicast PDSCHs with a gap	For any two consecutive slots n and n+1, if there are more than 1 unicast PDSCH in either slot, the minimum time separation between starting time of any two unicast PDSCHs within the duration of these slots is 4 OFDM symbol for 30kHz and 7 OFDM symbol for 60kHz	5-11, 5-11b, 5-13, or 5-13c	<i>pdsch-SeparationWithGap</i>	<i>FeatureSetDownlink-v1540</i>	No	No	This feature only applies to SCS 30kHz and 60kHz	Optional with capability signalling
5-33	Separation of two unicast PUSCHs with a gap	For any two consecutive slots n and n+1, if there are more than 1 unicast PUSCH in either slot, the minimum time separation between starting time of any two unicast PUSCHs within the duration of these slots is 2OFDM symbols for 15kHz, 4 OFDM symbols for 30kHz and 7 OFDM symbols for 60kHz	5-12, 5-12b, 5-13d, or 5-13f	<i>pusch-SeparationWithGap</i>	<i>FeatureSetUplink-v1540</i>	No	No	This feature only applies to SCS 15kHz, 30kHz and 60kHz	Optional with capability signalling
5-34	New 64QAM MCS table for PDSCH	New 64QAM MCS table for PDSCH		<i>dl-64QAM-MCS-TableAlt</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling
5-34a	New 64QAM MCS table for PUSCH	New 64QAM MCS tables for PUSCH with and without transform precoding respectively		<i>ul-64QAM-MCS-TableAlt</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Optional with capability signalling

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6. CA/DC, BWP, SUL	5-34b	Dynamic indication of MCS table with MCS-C-RNTI for PDSCH	Dynamic indication of MCS table using MCS-C-RNTI for PDSCH	5-34	<i>dl-MCS-TableAlt-DynamicIndication</i>	<i>FeatureSetDownlink-v1540</i>	n/a	n/a		Optional with capability signalling	
	5-34c	Dynamic indication of MCS tables with MCS-C-RNTI for PUSCH	Dynamic indication of MCS tables using MCS-C-RNTI for PUSCH	5-34a	<i>ul-MCS-TableAlt-DynamicIndication</i>	<i>FeatureSetUplink-v1540</i>	n/a	n/a		Optional with capability signalling	
	6-1	Basic BWP operation with restriction	1) 1 UE-specific RRC configured DL BWP per carrier 2) 1 UE-specific RRC configured UL BWP per carrier 3) RRC reconfiguration of any parameters related to BWP 4) BW of a UE-specific RRC configured BWP includes BW of CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell	n/a	n/a	n/a	n/a	n/a	This feature should be mandatory without capability signalling for at least BWPs which is the same as the set of specified channel BW UE-specific RRC configured DL/UL BWP can have the same or different numerology from the initial active DL/UL BWP	Mandatory without capability signalling	
	6-1a	BWP operation without restriction on BW of BWP(s)	BW of UE-specific RRC configured BWP may not include BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP may not include SSB for SCell	6-1, 6-2, 6-3, or 6-4	<i>bwp-WithoutRestriction</i>	<i>BandNR</i>	n/a	n/a	6-1a is applicable to 6-1, 6-2, 6-3, or 6-4.	Optional with capability signalling	
	6-2	Type A BWP adaptation with same numerology	1) Up to 2 UE-specific RRC configured DL BWPs per carrier 2) Up to 2 UE-specific RRC configured UL BWPs per carrier 3) Active BWP switching by DCI and timer 4) Same numerology for all the UE-specific RRC configured BWPs per carrier 5) BW of a UE-specific RRC configured BWP includes BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell	6-1	<i>upto2 in bwp-SameNumerology</i>	<i>BandNR</i>	n/a	n/a		Optional with capability signalling	

6-3	Type B BWP adaptation with same numerology	1) Up to 4 UE-specific RRC configured DL BWPs per carrier 2) Up to 4 UE-specific RRC configured UL BWPs per carrier 3) Active BWP switching by DCI and timer 4) Same numerology for all the UE-specific RRC configured BWPs per carrier 5) BW of a UE-specific RRC configured BWP includes BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell	6-1	<i>upto4 in bwp-SameNumerology</i>	<i>BandNR</i>	n/a	n/a		Optional with capability signalling
6-4	BWP adaptation with different numerologies	1) Up to 4 UE-specific RRC configured DL BWPs per carrier 2) Up to 4 UE-specific RRC configured UL BWPs per carrier 3) Active BWP switching by DCI and timer 4) More than one numerologies for the UE-specific RRC configured BWPs per carrier 5) Same numerology between DL and UL per cell except for SUL at a given time 6) BW of a UE-specific RRC configured BWP includes BW of the CORESET#0 (if CORESET#0 is present) and SSB for PCell/PSCell (if configured) and BW of the UE-specific RRC configured BWP includes SSB for SCell if there is SSB on SCell	6-1	<i>upto4 in bwp-DiffNumerology</i>	<i>BandNR</i>	n/a	n/a		Optional with capability signalling
6-5	Basic DL NR-NR CA operation	1) Up to16 DL carriers 2) Same numerology across carrier for data/control channel at a given time		<i>supportedBandCombinationList</i>	<i>RF-Parameters</i>	n/a	n/a	This is conditioned on the support of DL CA band combination(s).	Optional with capability signalling
6-5a	PDCCH blind detection capability for CA	1) More than 4 DL CCs 2) Reporting value is one of integer from 4 to 16	6-5	<i>pdccch-BlindDetectionCA</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	If UE supports CA with more than 4 DL CCs, UE should report this capability	{4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16}
6-6	Basic UL NR-NR CA operation	1) Up to16 UL carriers 2) Same numerology across carrier for data/control channel at a given time 3) One PUCCH group 4) Single TAG	6-5	<i>supportedBandCombinationList</i>	<i>RF-Parameters</i>	n/a	n/a	This is conditioned on the support of UL CA band combination(s). The terminology 'carrier' in the components in this FG does not refer to 'SUL'.	Optional with capability signalling

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	6-8	Different numerology across NR PUCCH groups	For both NR CA UE and EN-DC UE, different numerology between two NR PUCCH groups for data/control channel at a given time	6-5, 6-7	<i>diffNumerologyAcrossPUCCH-Group</i>	<i>CA-ParametersNR</i>	n/a	n/a	

6-9	Different numerologies across NR carriers within the same NR PUCCH group, with PUCCH on a carrier of smaller SCS	1) For both NR CA UE, EN-DC/NE-DC UE and NR-DC UEs, same numerology between DL and UL per carrier for data/control channel at a given time 2) For both NR CA UE and EN-DC/NE-DC UE with one NR PUCCH group, different numerologies across NR carriers within the same NR PUCCH groups up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with smaller SCS for data/control channel at a given time 3-1) For NR CA UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with smaller SCS for data/control channel at a given time 3-2) For EN-DC/NE-DC UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within an NR PUCCH group in FR1 wherein NR PUCCH is sent on the carrier with smaller SCS, and same numerology across NR carriers within another NR PUCCH group in FR2 for data/control channel at a given time 4) For NR DC UE, different numerologies across NR carriers within the same NR PUCCH group in MCG (in FR1) and up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with smaller SCS for data/control channel at a given time; and same numerology across NR carriers in SCG (in FR2).	6-5	<i>diffNumerologyWithinPUCCH-GroupSmallerSCS</i>	<i>CA-ParametersNR</i>	n/a	n/a	The terminologies 'UL' and 'carrier' in this FG do not refer to 'SUL'. NR PUCCH is sent on a carrier with SCS not larger than SCS of any DL carriers corresponding to the NR PUCCH group. The case with PUCCH on UL carrier with different numerologies within SCG is not supported for NR-DC.	Optional with capability signalling
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6-9a	Different numerologies across NR carriers within the same NR PUCCH group, with PUCCH on a carrier of larger SCS	1) For both NR CA UE, EN-DC/NE-DC UE and NR DC UEs, same numerology between DL and UL per carrier for data/control channel at a given time 2) For both NR CA UE and EN-DC/NE-DC UE with one NR PUCCH group, different numerologies across NR carriers within the same NR PUCCH groups up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is on the carrier with larger SCS for data/control channel at a given time 3-1) For NR CA UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with larger SCS for data/control channel at a given time 3-2) For EN-DC/NE-DC UE with two NR PUCCH groups, different numerologies across NR carriers up to two different numerologies within an NR PUCCH group in FR1 wherein NR PUCCH is sent on the carrier with larger SCS, and same numerology across NR carriers within another NR PUCCH group in FR2 for data/control channel at a given time 4) For NR DC UE, different numerologies across NR carriers within the same NR PUCCH group in MCG (in FR1) and up to two different numerologies within the same NR PUCCH group wherein NR PUCCH is sent on the carrier with larger SCS for data/control channel at a given time; and same numerology across NR carriers in SCG (in FR2).	6-5	diffNumerologyWithinPUCCH-GroupLargerSCS	CA-ParametersNR-v1560	n/a	n/a	The terminologies 'UL' and 'carrier' in this FG do not refer to 'SUL'. NR PUCCH is sent on a carrier with SCS not smaller than SCS of any DL carriers corresponding to the NR PUCCH group. The case with PUCCH on UL carrier with different numerologies within SCG is not supported for NR-DC.	Optional with capability signalling
6-10	Cross carrier scheduling for the same numerology	Cross carrier scheduling for the same numerology with CIF where numerologies for scheduling cell and scheduled cell are same	6-5, 6-6	crossCarrierScheduling-SameSCS	BandNR	n/a	n/a		
6-10a	Cross carrier scheduling for different numerologies	Cross carrier scheduling for the different numerologies with CIF where numerologies for scheduling cell and scheduled cell are different	6-10	crossCarrierScheduling-OtherSCS	FeatureSetDownlink FeatureSetUplink	n/a	n/a	This is not supported in Rel-15	

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6-11	Number of supported TAGs	Need of multiple capability question about the resolution here		<i>supportedNumberTAG</i>		<i>CA-ParametersNR</i>	n/a	n/a	This feature group is applied to NR-NR CA and EN-DC. For EN-DC, the feature group indicates number of TAGs only for NR CG.	{1, 2, 3, 4}		
6-12	Support 2 simultaneous UL transmissions for problematic cases	Support 2 simultaneous UL transmissions for problematic cases		<i>singleUL-Transmission</i>		<i>MRDC-Parameters</i>	n/a	n/a	The number of TAGs for the LTE MCG is signalled by existing LTE TAG capability signalling. This is a UE feature for LTE for a LTE/NR dual connectivity UE	Optional with capability signalling		
6-13	Case 1 Single Tx UL LTE-NR DC	1) Case 1: DL-reference UL/DL configuration defined for LTE-FDD-SCell in LTE-TDD-FDD CA with LTE-TDD-PCell 2) HARQ subframe offset		<i>tdm-Pattern</i> NOTE: This capability bit also indicates support of the feature 8-2, i.e. Operation A with single UL Tx case 1.		<i>MRDC-Parameters</i>	Yes	Yes	This is a UE feature for LTE for a LTE/NR dual connectivity UE	Mandatory with capability signalling conditional on the UE not supporting simultaneous dual-Tx operation in the band combination; optional if the UE supports simultaneous dual-Tx operation in the band combination		
6-16	Supplemental uplink	1) RACH, PUSCH, PUCCH, SRS operations in a band combination including SUL 2) Supplemental uplink with same numerology between SUL and non SUL carriers	6-15	<i>supportedBandCombinationList</i>		<i>RF-Parameters</i>	n/a	n/a	This is conditioned on the support of SUL band combination(s).	Optional with capability signalling		
6-17	Supplemental uplink with different numerologies between SUL and non SUL carriers	Different numerologies between SUL and non SUL	6-16	<i>supportedBandCombinationList</i>		<i>RF-Parameters</i>	n/a	n/a	This is conditioned on the support of SUL band combination(s).	Mandatory with capability signalling		
6-18	Supplemental uplink with dynamic switch	DCI based selection of PUSCH carrier	6-16	<i>dynamicSwitchSUL</i>		<i>FeatureSetUplink</i>	n/a	n/a	his is conditioned on the support of SUL band combination(s).	Optional with capability signalling		
6-19	Simultaneous transmission of SRS on an SUL/non-SUL carrier and PUSCH/PUCCH/SRS on the other UL carrier in the same cell	Simultaneous transmission of SRS on an SUL/non-SUL carrier and PUSCH/PUCCH/SRS on the other UL carrier in the same cell	6-16	<i>simultaneousTxSUL-NonSUL</i>		<i>FeatureSetUplink</i>	n/a	n/a		Optional with capability signalling		
6-21	DL search space sharing for CA	DL search space sharing for CA	6-10 or 6-10a	<i>searchSpaceSharingCA-DL</i>		<i>FeatureSetDownlink</i>	n/a	n/a		Optional with capability signalling		
6-22	UL search space sharing for CA	UL search space sharing for CA	6-10 or 6-10a	<i>searchSpaceSharingCA-UL</i>		<i>FeatureSetUplink</i>	n/a	n/a		Optional with capability signalling		
6-23	Incapability motivated by impacts of PA phase discontinuity with overlapping transmissions with non-aligned starting or ending times or hop boundaries across carriers for intra-band EN-DC, intra-band CA, and FDM based ULSUP	Incapability motivated by impacts of PA phase discontinuity with overlapping transmissions with non-aligned starting or ending times or hop boundaries across carriers for intra-band EN-DC, intra-band CA, and FDM based ULSUP		<i>pa-PhaseDiscontinuityImpacts</i>		<i>FeatureSetUplink-v1540</i>	n/a	n/a	See LS (R1-1809992)	Optional with capability signalling		

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6-24	Applying the same UL timing between NR and LTE	Applying the same UL timing between NR and LTE for dynamic power sharing capable UE operating in intra-band contiguous synchronous EN-DC	8-1	<i>ul-TimingAlignmentEUTRA-NR</i>	<i>MRDC-Parameters</i>	n/a	n/a	UEs that set this bit to 0 should be able to operate with a timing difference up to applicable MTTD requirements when operating in a synchronous intra-band contiguous EN-DC network. This is conditioned on the support of DC band combination(s). UE reports a set of supported band partitionings corresponding to MCG in FR1 and to SCG in FR2.	Optional with capability signalling
6-25	Support of synchronous NR-NR DC operation only wherein MCG is only in FR1 and SCG is only in FR2	Support of synchronous NR-NR DC operation only wherein MCG is only in FR1 and SCG is only in FR2		<i>ca-ParametersNRDC</i>	<i>BandCombination-v1560</i>	n/a	n/a		Optional with capability signalling

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6-25a	PDCCH blind detection capability for MCG and for SCG in synchronous NR-DC	RRC parameters <i>pdccch-BlindDetectionMCG-UE</i> and <i>pdccch-BlindDetectionSCG-UE</i> for optional new UE capability signalling that informs the maximum values for <i>pdccch-BlindDetectionMCG</i> and <i>pdccch-BlindDetectionSCG</i> , respectively	6-5, 6-25	<i>pdccch-BlindDetectionMCG-UE</i> <i>pdccch-BlindDetectionSCG-UE</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	<p><i>pdccch-BlindDetectionMCG-UE</i> and <i>pdccch-BlindDetectionSCG-UE</i> are per UE capability signalling.</p> <p>The value range of <i>pdccch-BlindDetectionMCG-UE</i> and <i>pdccch-BlindDetectionSCG-UE</i> is</p> <ul style="list-style-type: none"> - [1, ..., <i>pdccch-BlindDetectionCA</i>-1] and <i>pdccch-BlindDetectionMCG-UE</i> + <i>pdccch-BlindDetectionSCG-UE</i> >= <i>pdccch-BlindDetectionCA</i> if the UE reports <i>pdccch-BlindDetectionCA</i>, and - [1, 2, 3] and <i>pdccch-BlindDetectionMCG-UE</i> + <i>pdccch-BlindDetectionSCG-UE</i> >= the maximum number of DL serving cells over CGs that UE can support if the UE does not report <i>pdccch-BlindDetectionCA</i>. <p>If the UE does not report <i>pdccch-BlindDetectionMCG-UE</i> and <i>pdccch-BlindDetectionSCG-UE</i>,</p> <ul style="list-style-type: none"> - <i>pdccch-BlindDetectionCA</i> for NR-CA is re-used as the UE capability signalling for NR-DC to determine BD/CCE limit across serving cells over CGs if the UE reports <i>pdccch-BlindDetectionCA</i>, and - the number of configured DL serving cells over CGs is used to determine BD/CCE limit across serving cells over CGs if the UE does not report <i>pdccch-BlindDetectionCA</i>. <p>If the UE reports <i>pdccch-</i></p>	Optional with capability signalling

										<i>BlindDetectionMCG-UE or pdcch-BlindDetectionSCG-UE</i> , both of them are reported (i.e., not either of them).	
7. Channel coding	7-1	Channel coding	1) LDPC encoding and associated functions for data on DL and UL 2) Polar encoding and associated functions for PBCH, DCI, and UCI 3) Coding for very small blocks		n/a	n/a	n/a	n/a			Mandatory without capability signalling
8. UL TPC	8-1	Dynamic power sharing for LTE-NR DC	When total transmission power exceeds P _{cm} _{ax} , UE scales NR transmission power.	EN-DC	<i>dynamicPowerSharing</i>	<i>MRDC-Parameters</i>	n/a	n/a	RP-172833		Mandatory with capability signalling
	8-2	Operation A with single UL Tx case 1	Operation A with single UL Tx case 1	EN-DC	<i>tdm-Pattern</i> NOTE: This capability bit also indicates support of the feature 6-13, i.e. Case 1 Single Tx UL LTE-NR DC.	<i>MRDC-Parameters</i>	Yes	Yes	RP-172833		Mandatory with capability signalling conditioned that UE does not support dynamic power sharing, i.e., UE indicate "0" as non-support for 8-1, optional for UEs supporting dynamic power sharing Mandatory without capability signalling
	8-3	Basic power control operation	1) Accumulated power control mode for closed loop 2) 1 TPC command loop for PUSCH, PUCCH respectively 3) One or multiple DL RS configured for pathloss estimation 4) One or multiple p ₀ -alpha values configured for open loop PC 5) PUSCH power control 6) PUCCH power control 7) PRACH power control 8) SRS power control 9) PHR		n/a	n/a	No	No			
	8-4	TPC-PUSCH-RNTI	Specific group DCI message for TPC commands for PUSCH		<i>tpc-PUSCH-RNTI</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes			Optional with capability signalling
	8-5	TPC-PUCCH-RNTI	Specific group DCI message for TPC commands for PUCCH		<i>tpc-PUCCH-RNTI</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes			Optional with capability signalling
	8-6	TPC-SRS-RNTI	Specific group DCI message for TPC commands for SRS		<i>tpc-SRS-RNTI</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes			Optional with capability signalling
	8-7	Absolute TPC command mode	Absolute TPC command mode		<i>absoluteTPC-Command</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes			Optional with capability signalling
	8-8	UL power control with 2 PUSCH closed loops	Two different TPC loops		<i>twoDifferentTPC-Loop-PUSCH</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes			Mandatory with capability signalling
	8-9	UL power control with 2 PUCCH closed loops	Two different TPC loops		<i>twoDifferentTPC-Loop-PUCCH</i>	<i>Phy-ParametersXDD-Diff</i> <i>Phy-ParametersFRX-Diff</i>	Yes	Yes			Mandatory with capability signalling

4.2 Layer-2 and Layer-3 features

Table 4.2-1 provides the list of Layer-2 and Layer-3 features, as shown in [4] and the corresponding UE capability field name, as specified in TS 38.331 [2].

Table 4.2-1: Layer-2 and Layer-3 feature list

Release 15	51				3GPP TR 38.822 V15.0.1 (2019-07)					
Features	Index	Feature group	Components	Prerequisite feature groups	Field name in TS 38.331 [2]	Parent IE in TS 38.331 [2]	Need of FDD/TDD differentiation	Need of FR1/FR2 differentiation	Note	Mandatory/Optional
0. General (including supported bearer types)	0-0	Basic EN-DC procedures	1) MCG DRB with LTE/NR PDCP 2) SCG DRB with NR PDCP 3) SN addition, modification, and release via RRC connection reconfiguration 4) Joint processing on the combined RRC messages 5) Failure handling (including both MN and SN)		n/a	n/a	n/a	n/a		Mandatory without capability signalling
	0-1	Access stratum release	Access stratum release		<i>accessStratumRelease</i>	<i>UE-NR-Capability</i>	No	No		Optional with capability signalling and candidate value set is {Rel-15, spare7, ... , spare1}
	0-2	SRB	1) Split SRB with one UL path 2) SRB3		1) <i>splitSRB-WithOneUL-Path</i> 2) <i>srb3</i>	<i>GeneralParametersMRDC-XDD-Diff</i>	No	No	2) Not applied to NE-DC.	1) Optional with capability signalling 2) Mandatory with capability signalling
	0-3	DRB	1) Maximum number of DRBs 2) Split DRB with one UL path 3) Split DRB with both UL MCG and SCG paths		1), 2) n/a 3) <i>splitDRB-withUL-Both-MCG-SCG</i>	1), 2) n/a 3) <i>GeneralParametersMRDC-XDD-Diff</i>	No	No	2) 8 DRBs are supported regardless of bearer types	1, 2) Mandatory without UE capability signalling 3) Mandatory with capability signalling
	0-4	Direct SN addition in the first RRC connection reconfiguration after RRC connection establishment	Direct SN addition in the first RRC connection reconfiguration after RRC connection establishment		n/a	n/a	n/a	n/a		Mandatory without capability signalling
	0-5	IMS voice	1) IMS voice over NR 2) Fallback HO to LTE for IMS voice 3) 5GC VoLTE 4) IMS voice over SCG bearer of NE-DC		1) <i>voiceOverNR</i> 3) <i>voiceOverEUTRA-5GC</i> 4) <i>voiceOverSCG-BearerEUTRA-5GC</i>	1) <i>IMS-ParametersFRX-Diff</i> 3), 4) <i>IMS-ParametersCommon</i>	1), 3), 4) No	1) Yes 3), 4) No	1), 2), 3) SA only 4): NE-DC only	1) Mandatory with capability signalling if UE is IMS voice capable in NR SA. Otherwise optional with capability signalling. 2) No need for a separate capability signalling. 3) Optional with capability signalling 4) Optional with capability signalling
	0-6	Delay budget reporting	Delay budget reporting		<i>delayBudgetReporting</i>	<i>UE-NR-Capability-v1530</i>	No	No	SA only	Optional with capability signalling
	0-7	PCell operation	1) PCell operation on FR2		<i>pCell-FR2</i>	<i>Phy-ParametersFR2</i>	No	No	SA only	Mandatory with capability signalling
	0-8	Overheating	1) Overheating assistance information		<i>overheatingInd</i>	<i>UE-NR-Capability-v1540</i>	No	No	SA only	Optional with capability signalling
	0-9	V2X	1) Support of EUTRA V2X		<i>v2x-EUTRA</i>	<i>GeneralParametersMRDC-XDD-Diff</i>	Yes	No	Only applied to EN-DC	Optional with capability signalling
1. PDCP	1-0	Basic PDCP procedures	1) (de)Ciphering on DRB/SRB 2) Integrity protection on SRB 3) Timer based SDU discard 4) Re-ordering and in-order delivery 5) Status reporting 6) Duplicate discarding 7) 18bits SN		n/a	n/a	n/a	n/a		Mandatory without capability signalling

Release 15	52						3GPP TR 38.822 V15.0.1 (2019-07)	
	1-1	ROHC context	1) Maximum number of ROHC context sessions 2) Supported ROHC profiles	1) <i>maxNumberOfROHC-ContextSessions</i> 2) <i>supportedROHC-Profiles</i>	<i>PDCP-Parameters</i>	No	No	Optional with capability signalling and candidate value set is: 1) {cs2, cs4, cs8, cs12, cs16, cs24, cs32, cs48, cs64, cs128, cs256, cs512, cs1024, cs16384, spare2, spare1} 2) {0x0000, 0x0001, 0x0002, 0x0003, 0x0004, 0x0006, 0x0101, 0x0102, 0x0103, 0x0104}
	1-2	ROHC context continuation operation	ROHC context continuation operation	<i>continueROHC-Context</i>	<i>PDCP-Parameters</i>	No	No	Optional with capability signalling
	1-3	Uplink only ROHC profiles	Uplink only ROHC profiles	<i>uplinkOnlyROHC-Profiles</i>	<i>PDCP-Parameters</i>	No	No	Optional with capability signalling
	1-4	Out of order delivery	Out of order delivery	<i>outOfOrderDelivery</i>	<i>PDCP-Parameters</i>	No	No	Optional with capability signalling
	1-5	Short SN	Short SN	<i>shortSN</i>	<i>PDCP-Parameters</i>	No	No	Mandatory with capability signalling
	1-6	PDCP duplication	1) PDCP duplication for split SRB1/2 2) PDCP duplication for SRB1/2 and/or SRB3 3) PDCP duplication for MCG or SCG DRB 4) PDCP duplication for split DRB	1) <i>pdcp-DuplicationSplitSRB</i> 2) <i>pdcp-DuplicationSRB</i> 3) <i>pdcp-DuplicationMCG-OrSCG-DRB</i> 4) <i>pdcp-DuplicationSplitDRB</i>	1), 4) <i>PDCP-ParametersMRDC</i> 2), 3) <i>PDCP-Parameters</i>	No	No	Optional with capability signalling
	1-7	DRB IP data rate	1) DRB IP data rate in DL 2) DRB IP data rate in UL	n/a	n/a	n/a	n/a	Optional capability is signalled by NAS signalling defined in 24.501
2. RLC	2-0	Basic RLC procedures	1) RLC TM 2) RLC AM with 18bits SN* 3) SDU discard	n/a	n/a	n/a	n/a	No separate feature is considered for t-PollRetransmit, t-Reassembly and t-StatusProhibit Mandatory without capability signalling
	2-1	RLC AM with short SN	RLC AM with short SN	<i>am-WithShortSN</i>	<i>RLC-Parameters</i>	No	No	Mandatory with capability signalling
	2-2	RLC UM with short SN	RLC UM with short SN	<i>um-WithShortSN</i>	<i>RLC-Parameters</i>	No	No	Mandatory with capability signalling
	2-3	RLC UM with long SN	RLC UM with long SN	<i>um-WithLongSN</i>	<i>RLC-Parameters</i>	No	No	Mandatory with capability signalling
	2-4	NR RLC SN size for SRB	NR RLC SN size for SRB	n/a	n/a	n/a	n/a	RAN2 decided only short RLC SN is used for SRB.

Release 15	53						3GPP TR 38.822 V15.0.1 (2019-07)	
3. MAC	3-0	Basic MAC procedures	1) RA procedure on PCell or PSCell (in case of EN-DC) 2) UE initiated RA procedure (including for beam recovery purpose) 3) NW initiated RA procedure (i.e. based on PDCCH) 4) Support of ssb-Threshold and association between preamble/PRACH occasion and SSB 5) Preamble grouping 6) UL single TA maintenance 7) HARQ operation for DL and UL 8) LCH prioritization 9) Prioritized bit rate 10) Multiplexing 11) SR with single SR configuration 12) BSR 13) PHR 14) 8bits and 16bits L field	n/a	n/a	n/a	n/a	Mandatory without capability signalling
4. Measurements	3-1	LCP restriction	1) LCP restriction 2) LCP restriction to SCell(s)	1) <i>lcp-Restriction</i> 2) <i>lch-ToSCellRestriction</i>	<i>MAC-ParametersCommon</i>	No	No	Optional with capability signalling
	3-2	LCH SR delay timer	LCH SR delay timer	<i>logicalChannelSR-DelayTimer</i>	<i>MAC-ParametersXDD-Diff</i>	Yes	No	Optional with capability signalling
	3-3	DRX	1) DRX with long DRX cycle 2) DRX with short DRX cycle	1) <i>longDRX-Cycle</i> 2) <i>shortDRX-Cycle</i>	<i>MAC-ParametersXDD-Diff</i>	Yes	No	Mandatory with capability signalling
	3-4	Configured grants	Maximum number of configured grant configurations per cell group	<i>multipleConfiguredGrants</i>	<i>MAC-ParametersXDD-Diff</i>	Yes	No	Optional with capability signalling
	3-5	SR	Multiple SR configurations	<i>multipleSR-Configurations</i>	<i>MAC-ParametersXDD-Diff</i>	Yes	No	Optional with capability signalling
	3-6	Skipping UL transmission	1) Skipping UL transmission for dynamic UL grant 2) Skipping UL transmission for configured UL grant	1) <i>skipUplinkTxDynamic</i>	<i>MAC-ParametersXDD-Diff</i>	1) Yes 2) No	No	1) Optional with capability signalling. Mandatory with capability signalling from Rel-16 2) Conditional mandatory if the UE supports configured grant
	3-7	Codec adaptation	1) Bit rate recommendation message 1) Bit rate recommendation query message	1) <i>recommendedBitRate</i> 2) <i>recommendedBitRateQuery</i>	<i>MAC-ParametersCommon</i>	No	No	SA only Optional with capability signalling
	4-1	Intra-NR measurements and reports	1) Intra-frequency and inter-frequency measurements and reports 2) Event A-based measurement and measurement report	1) <i>intraAndInterF-MeasAndReport</i> 2) <i>eventA-MeasAndReport</i>	<i>MeasAndMobParametersXDD-Diff</i>	Yes	No	Mandatory with capability signalling when EN-DC is configured. Mandatory without capability signalling for NR SA.
	4-2	Inter-NR measurement and reports while in LTE connected	1) NR measurement and reports while in LTE connected 2) Event B1-based measurement and reports while in LTE connected	n/a	n/a	n/a	n/a	Mandatory without capability signalling
	4-3	SFTD measurements	1) SFTD measurements between PCell and PSCell 2) SFTD measurements between PCell and NR Cell	1) <i>sftd-MeasPSCell</i> 2) <i>sftd-MeasNR-Cell</i>	<i>MeasAndMobParametersMRDC-XDD-Diff</i>	Yes	No	Optional with capability signalling
	4-4	Measurement gaps	Additional measurement gap configurations	<i>supportedGapPattern</i>	<i>MeasAndMobParametersCommon</i>	No	No	Optional with capability signalling and candidate value set is: BIT STRING (SIZE (22))

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5. SDAP	4-5	ANR	1) CGI reporting of EUTRA cell when EN-DC is not configured 2) CGI reporting of NR cell when EN-DC is not configured 3) CGI reporting of NR cell when EN-DC is configured	1) <i>eutra-CGI-Reporting</i> 2) <i>nr-CGI-Reporting</i> 3) <i>nr-CGI-Reporting-ENDC</i>	<i>MeasAndMobParametersCommon</i>	No	No	1) and 2) SA only 3) EN-DC only	Mandatory with capability signalling
								Autonomous gap is not supported when ANR (towards NR neighbour cells) configured by NR PCell in NR SA and when ANR (towards NR neighbouring cells) configured by NR PSCell in EN-DC.	
	4-6	LTE measurement and reporting while in NR connected	1) Periodic measurement and reporting while NR connected. 2) Event B#N-based measurement and reporting while NR connected	1) <i>periodicEUTRA-MeasAndReport</i> 2) <i>eventB-MeasAndReport</i>	<i>MeasAndMobParametersCommon</i>	No	No		Mandatory with capability signalling if the UE supports LTE
	5-1	QoS	1) Flow-based QoS 2) Multiple flows to 1 DRB mapping 3) AS reflective QoS	3) <i>as-ReflectiveQoS</i>	<i>SDAP-Parameters</i>	No	No	SA only	1), 2) Mandatory without capability signalling 3) Optional with capability signalling
	5-2	HD format	1) DL SDAP HD 2) UL SDAP HD 3) SDAP End-marker	n/a	n/a	n/a	n/a	SA only	1) Conditional mandatory if either NAS reflective QoS or AS reflective QoS is supported. No capability signalling is needed. 2), 3) Mandatory without capability signalling
6. Inactive	6-1	RRC inactive	RRC inactive	<i>inactiveState</i>	<i>UE-NR-Capability-v1530</i>	No	No	SA only	Mandatory with capability signalling
7. Mobility	7-1	Handover	1) Intra-frequency HO 2) Inter-frequency HO 3) HO between TDD and FDD 4) HO from NR to LTE 5) HO from NR to LTE with 5GC 6) HO between FR1 and FR2	2) <i>handoverInterF</i> 3) <i>handoverFDD-TDD</i> 4) <i>handoverLTE-EPC</i> 5) <i>handover-LTE-5GC</i> 6) <i>handoverFR1-FR2</i>	3), 6) <i>MeasAndMobParametersCommon</i> 2), 4), 5) <i>MeasAndMobParametersXDD-Diff</i> and <i>MeasAndMobParametersFRX-Diff</i>	1), 3), 6) No 2), 4), 5) Yes	1), 3), 6) No 2), 4), 5) Yes	SA only	1) Mandatory without capability signalling 2) Mandatory with capability signalling 3) Mandatory with capability signalling if the UE supports both TDD and FDD. 4) and 5) Mandatory with capability signalling if the UE supports the associated RAT. 6) Mandatory with capability signalling if the UE supports both FR1 and FR2.
8. Idle/inactive UE procedures	8-1	System information acquisition	1) Msg.1 based on-demand SI provisioning 2) Msg.3 based on-demand SI provisioning	n/a	n/a	n/a	n/a	SA only	Mandatory without capability signalling
9. RRC	9-1	RRC buffer size	Maximum overall RRC configuration size	n/a	n/a	n/a	n/a		45 Kbytes

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	9-2	RRC processing time	1) RRC connection establishment 2) RRC connection resume without SCell addition/release and SCG establishment/modification/release 3) RRC connection reconfiguration without SCell addition/release and SCG establishment/modification/release 4) RRC connection re-establishment. 5) RRC connection reconfiguration with sync procedure 6) RRC connection reconfiguration with SCell addition/release or SCG establishment/modification/release 7) RRC connection resume 8) Initial security activation 9) Counter check 10) UE capability transfer	n/a		n/a		n/a	1) to 3) 10ms 4) 10ms 5): 10ms + additional delay (cell search time and synchronization) defined in TS 38.133 6) and 7) 16ms 7) 10 or 6ms (See details in 12, TS 38.331) 8) and 9) 5ms 10) 80ms
10. Architecture options	10-1	NE-DC	Support of NE-DC	ne-DC	EUTRA-ParametersCommon	No	No	Only applied to NE-DC. Note for EN-DC, it is included in EUTRA side.	Optional with capability signalling
	10-2	NR-DC	Support of NR-DC	ne- DC-BC	BandCombination-v1560				
				ca-ParametersNRDC	BandCombination-v1560	No	No		Optional with capability signalling

4.3 RF and RRM features

Table 4.3-1 provides the list of RF and RRM features, as shown in [5] and the corresponding UE capability field name, as specified in TS 38.331 [2].

Table 4.3-1: RF and RRM feature list

Release 15		57					3GPP TR 38.822 V15.0.1 (2019-07)			
Features	Index	Feature group	Components	Prerequisite feature groups	Field name in TS 38.331 [2]	Parent IE in TS 38.331 [2]	Need of FDD/TDD differentiation	Need of FR1/FR2 differentiation	Note	Mandatory/Optional
1. System parameter	1-1	60kHz of subcarrier spacing for FR1	60kHz subcarrier spacing for data channel in FR1		<i>scs-60kHz</i>	<i>Phy-ParametersFR1</i>	No	Applicable only to FR1	Capability can be discussed in future, e.g. when low cost device (e.g. IoT) and/or higher frequency band in FR2 are introduced	Optional with capability signalling
	1-2	64QAM modulation for FR2 PDSCH	64QAM modulation for FR2 PDSCH		n/a	n/a	No	Applicable only to FR2		Mandatory without capability signalling
	1-3	64QAM for PUSCH	64QAM for PUSCH		n/a	n/a	No	No	Capability can be discussed in future, e.g. when low cost device (e.g. IoT) and/or higher frequency band in FR2 are introduced	Mandatory without capability signalling
	1-4	256QAM for PDSCH	256QAM for PDSCH		<i>pdsch-256QAM-FR1</i>	<i>Phy-ParametersFR1</i>	No	Yes	For FR1, it can be revisited in the future whether the 256QAM is mandated in all UE types or categories	Mandatory with capability signalling for FR1
					<i>pdsch-256QAM-FR2</i>	<i>BandNR</i>			For FR2, RAN4 agreed that no BS and UE requirements will be introduced in Rel.15.	Optional with capability signalling for FR2
	1-5	256QAM for PUSCH	256QAM for PUSCH		<i>pusch-256QAM</i>	<i>BandNR</i>	No	Yes	For FR1, RAN4 can further discuss to mandate 256QAM for PUSCH for FR1 in future release. For FR2, RAN4 agreed that no BS and UE requirements will be introduced in Rel.15.	Optional with capability signalling (for both FR1 and FR2)
	1-6	pi/2-BPSK for PUSCH	pi/2-BPSK for PUSCH		<i>pusch-HalfPi-BPSK</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	RAN4 will define the same minimum requirements for pulse-shaped pi/2 BPSK and non-pulse shaped pi/2 BPSK for FR2.	Optional with capability signalling for FR1
	1-7	pi/2-BPSK for PUCCH format 3/4	pi/2-BPSK for PUCCH format 3/4		<i>pucch-F3-4-HalfPi-BPSK</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes		Mandatory with capability signalling for FR2 Optional with capability signalling for FR1
	1-8	Active BWP switching delay	Support of active BWP switching delay specified in TS38.133, candidate values set: {type1, type2}		<i>bwp-SwitchingDelay</i>	<i>Phy-ParametersCommon</i>	No	No	For this feature, RAN4 also sent another LS (R4-1803283). Network cannot configure the shorter delay for certain UE type.	Mandatory with capability signalling for FR2 Mandatory to support either type 1 or type 2 with capability signalling
1-9	Support of EN-DC with LTE-NR coexistence in UL sharing from UE perspective	1) LTE and NR UL Transmission in the shared carrier via TDM only 2) LTE and NR UL Transmission in the shared carrier via FDM only 3) LTE and NR UL transmission in the shared carrier via FDM or TDM	<i>ul-SharingEUTRA-NR</i>	<i>MRDC-Parameters</i>	No	Applicable only to FR1		Optional with capability signalling		

Release 15					58				3GPP TR 38.822 V15.0.1 (2019-07)
	1-10	Switching time between LTE UL and NR UL for EN-DC with LTE-NR coexistence in UL sharing from UE perspective	Support of switching type between LTE UL and NR UL for EN-DC with LTE-NR coexistence in UL sharing from UE perspective. Type 1: <0.5us Type 2: <20us	1-9	<i>ul-SwitchingTimeEUTRA-NR</i>	<i>MRDC-Parameters</i>	No	Applicable only to FR1	<p>This feature is the switching time between LTE UL and NR UL in the same carrier</p> <p>Per band combination signalling</p> <p>UE Capability signalling elements. 1: <0.5us switching type. 2: <20us switching type.</p> <p>Mandatory to support either type 1 or type 2 with capability signalling if UE reports its capability in 1-10 as 1) LTE and NR UL Transmission in the shared carrier via TDM only, or 3) LTE and NR UL transmission in the shared carrier via FDM or TDM</p> <p>Mandatory in the SUL bands with uplink sharing either from UE perspective or from network perspective</p> <p>7.5KHz raster shift as mandatory without capability signalling. 7.5kHz UL raster shift is mandatory for the bands described in clause 5.4.2.1 of Release 15 TS 38.101-1. RAN4 can revisit the above bands in the future release. 7.5KHz raster shift is not mandatory for other LTE refarming band except the bands which were agreed to support 7.5kHz UL raster shift as mandatory</p>
	1-11	7.5kHz UL raster shift	7.5kHz UL raster shift		n/a	n/a	No	No	
2. UE RF	2-1	Maximum channel bandwidth supported in each band for DL and UL separately and for each SCS that UE supports within a single CC	1) FR1 channel bandwidths in TS38.101-1 Table 5.3.5-1 2) FR2 channel bandwidths in TS38.101-2 Table 5.3.5-1		<i>channelBW</i> s-DL <i>channelBW</i> s-UL	<i>BandNR</i>	No	No	<p>UE capability signalling shall follow RP-172832 (Per-band capability signalling, separately for DL and UL and for each SCS)</p> <p>Whether a bandwidth newly introduced in future is mandatory for UE shall be discussed case by case.</p> <p>For FR1, all the bandwidths listed in TS38.101-1 v15.0.0 Table 5.3.5-1 for each band shall be mandatory with a single CC. The bandwidths listed in the slide #3 of R4-1805985 are mandatory with a single CC. 90MHz is optional for n41, n77, n78.</p> <p>For FR2, the set of mandatory CBW is 50, 100, 200 MHz.</p>
					<i>supportedBandwidthDL</i> <i>channelBW</i> -90mhz	<i>FeatureSetDownlinkPerCC</i>			
					<i>supportedBandwidthUL</i> <i>channelBW</i> -90mhz	<i>FeatureSetUplinkPerCC</i>			

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2-2	Simultaneous reception or transmission with same or different numerologies in CA	Support of simultaneous reception or transmission with same or different numerologies in CA	<i>supportedSubcarrierSpacingDL</i>	<i>FeatureSetDownlinkPerCC</i>	No	No	From RAN4 perspective UE shall be able to signal the supported SCS per CC for each band combination	Same numerology for intra-band NR CA including both continuous and non-continuous is mandatory with capability in both FR1 and FR2. Two mixed numerologies between FR1 band(s) and FR2 band(s) in DL and UL are mandatory with capability if UE supports inter-band NR CA including both FR1 band(s) and FR2 band(s). Optional for other cases.	
							Same numerology for intra-band NR CA including both continuous and non-continuous is mandatory support for Rel15		
			<i>supportedSubcarrierSpacingUL</i>	<i>FeatureSetUplinkPerCC</i>			The capability of supporting SCS within the single carrier in the CA configuration will be signalled separately, i.e., there is no need to mandatory UE to support mixed numerologies in CA case		
2-3	Non-contiguous intra-band CA frequency separation class for FR2	1) Support of frequency separation classes to handle the total frequency span for DL for intra-band non-contiguous CA 2) Support of frequency separation classes to handle the total frequency span for UL for intra-band non-contiguous CA	<i>intraBandFreqSeparationDL</i>	<i>FeatureSetDownlink</i>	No	Applicable only to FR2	UE signals the supported Frequency separation classes with per band granularity (Type 1) based on R4-1803363	Mandatory to support a frequency separation class within {I, II, III} specified in TS38.101-2 with capability if UE supports non-contiguous CA in FR2	
			<i>intraBandFreqSeparationUL</i>	<i>FeatureSetUplink</i>			Separate Frequency separation classes can be signalled for DL and UL		
2-4	Simultaneous reception and transmission for inter-band EN-DC (TDD-TDD or TDD-FDD)	Simultaneous reception and transmission for inter-band EN-DC (TDD-TDD or TDD-FDD)	<i>simultaneousRxTxInterBandENDC</i>	<i>MRDC-Parameters</i>	No	No	For TDD-FDD and TDD-TDD band combinations for which simultaneous RxTx capability is agreed to be supported, corresponding capability indication must be set to "supported".	Mandatory/Optional support depends on band combination and captured in TS 38.101-3	
							Band combinations for which simultaneous RxTx capability is mandatory EN-DC combinations (Both FR1 LTE – FR1 NR and FR1 LTE- FR2 NR) are captured in TS 38.101-3.		

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	2-5	Simultaneous reception and transmission for inter band CA (TDD-TDD or TDD-FDD)	Simultaneous reception and transmission for inter band CA (TDD-TDD or TDD-FDD)	<i>simultaneousRxTxInterBandCA</i>	<i>CA-ParametersNR</i>	No	No	For TDD-FDD and TDD-TDD band combinations for which simultaneous RxTx capability is agreed to be supported, corresponding capability indication must be set to "supported".	Mandatory/Optional support depends on band combination and captured in TS 38.101-1, TS 38.101-2 and TS 38.101-3
	2-6	Asynchronous FDD-FDD intra-band EN-DC DC	Asynchronous FDD-FDD intra-band EN-DC	<i>asynclntraBandENDC</i>	<i>MRDC-Parameters</i>	Applicable only to FDD	Applicable only to FR1	Band combinations for which simultaneous RxTx capability is mandatory are captured in TS 38.101-1, TS 38.101-2 and TS 38.101-3.	Optional with capability signalling
	2-7	Almost contiguous UL CP-OFDM	Support of almost contiguous UL CP-OFDM transmissions	<i>almostContiguousCP-OFDM-UL</i>	<i>Phy-ParametersFRX-Diff</i>	No	Yes	RAN4 had defined the requirements for "Almost contiguous UL CP-OFDM" in Rel-15.	Optional with capability signalling
	2-8	UE power class	1) Support of FR1 UE power class 2) Support of FR2 UE power class 3) Support of FR1 UE power class for EN-DC 4) Support of FR1 UE power class for NR-CA	<i>ue-PowerClass</i>	<i>BandNR</i>	No	No	Capability signalling - FR1 UE power class (per band) - FR2 UE power class (per band) - FR1 UE power class for EN-DC (per band combination) - FR1 UE power class for NR CA (per band combination)	Mandatory to support at least one power class with capability. The capability signalling is absent if UE supports only default power class
				<i>powerClass</i>	<i>BandCombination</i>			Default power class for each component is indicated in TS38.101-1/2/3. If the default power class is not indicated, UE shall report supported power class. The component 2) is also used as power class for intra-band NR-CA in FR2	
	2-9	Simultaneous reception and transmission for SA SUL band combinations	Simultaneous reception and transmission for SA SUL band combinations	<i>simultaneousRxTxSUL</i>	<i>CA-ParametersNR</i>	No	No		Mandatory/Optional support depends on band combination and captured in TS 38.101-1
	2-10	Multiple frequency band indication	Multiple frequency band indication	n/a	n/a	No	No	Per UE capability	Mandatory without capability signalling
	2-11	Modified MPR behaviour	Modified MPR behaviour	<i>modifiedMPR-Behaviour</i>	<i>BandNR</i>	No	No	Per band capability	Optional with capability signalling
	2-12	Multiple NS/P-Max	Multiple NS/P-Max	n/a	n/a	No	No	Per UE capability	Mandatory without capability signalling

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2-13	Maximum uplink duty cycle for FR1 power class 2 UE	Maximum percentage of uplink symbols can be scheduled within a certain evaluation period provided by regulatory bodies. The value range is {60%, 70%, 80%, 90%, 100%}. If the field is absent, 50% shall be applied.		<i>maxUplinkDutyCycle-PC2-FR1</i>	<i>BandNR</i>	No	Applicable only to FR1	Per band capability. If this capability is absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than 50%, or this capability is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than this capability, apply all requirements for the default power class. The evaluation period is up to UE implementation, no less than one radio frame. UE do not need to do UL duty cycle calculation when it's transmit power is below 23dBm and all the UL/DL configurations can be scheduled.	Optional with capability signalling. The capability signalling is absent if UE supports 50%
2-14	Power boosting for Pi/2 BPSK for power class 3 UE	Power boosting for Pi/2 BPSK for power class 3 UE in TDD bands n40, n77, n78 and n79 with duty cycle less than 40%	1-6, 1-7	<i>powerBoosting-pi2BPSK</i>	<i>BandNR</i>	Applicable only to TDD	Applicable only to FR1	Per band capability	Optional with capability signalling
2-15	Maximum uplink duty cycle for FR2	1) Maximum percentage of uplink transmission time that can be scheduled within 1s time window in order to ensure compliance with applicable electromagnetic power density exposure requirements provided by regulatory bodies. The value range is {15%, 20%, 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%}.		<i>maxUplinkDutyCycle-FR2</i>	<i>BandNR</i>	No	Applicable only to FR2	Per band capability. If the field of UE capability is present and the percentage of uplink symbols transmitted within any 1 s evaluation period is larger than this capability, the UE follows the uplink scheduling and can apply P-MPR as in TS38.101-2. If the field of UE capability is absent, the compliance to electromagnetic power density exposure requirements are ensured by means of scaling down the power density or by other means. This capability is applicable for all power classes in FR2	Optional with capability signalling

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	2-16	PA architectures for intra-band EN-DC	Support of dual PA	<i>dualPA-Architecture</i>	<i>MRDC-Parameters</i>	No	No	Per band per band combination capability Single PA is default architecture The following requirements are involved by this capability - A-MPR/MPR and MSD values for dual uplink. Whether two sets of requirements will be introduced in RAN4 can be further discussed for each specific band combination - Switching time between LTE UL and NR UL in single switched UL operation mode for intra-band EN-DC	Mandatory to support either single or dual PA architectures with capability if UE supports intra-band EN-DC configuration in uplink. The capability signalling is absent if UE supports single PA architecture.	
	2-17	PA architectures for intra-band UL CA	Support of dual PA	<i>dualPA-Architecture</i>	<i>CA-ParametersNR-v1540</i>	No	No	Per band per band combination capability Single PA is default architecture The following requirements are involved by this capability - A-MPR/MPR and MSD values for dual uplink. Whether two sets of requirements will be introduced in RAN4 can be further discussed for each specific band combination	Mandatory to support either single or dual PA architectures with capability if UE supports intra-band CA configuration in uplink. The capability signalling is absent if UE supports single PA architecture	
3. Baseband	3-1	Independent measurement gap configurations for FR1 and FR2	Measurement gaps for FR1 and FR2 are configured independently.	<i>independentGapConfig</i>	<i>MeasAndMobParametersMRDC-Common</i>	No	No		Optional with capability signalling	
	3-2	Simultaneous reception of data and SS block with different numerologies when UE conducts the serving cell measurement or intra-frequency measurement	Simultaneous reception of data and SS block with different numerologies when UE conducts the serving cell measurement or intra-frequency measurement	<i>simultaneousRxDataSSB-DiffNumerology</i>	<i>MeasAndMobParametersFRX-Diff</i> <i>MeasAndMobParametersMRDC-FRX-Diff</i>	No	Yes		Optional with capability signalling	
	3-3	Short measurement gap	Measurement gap patterns with short MGL (gap pattern#2, 3, 6, 7, 8, 10) are supported for E-UTRAN measurement. Gap patterns #6, 7, 8, 10 only apply to E-UTRAN measurement when MO includes both E-UTRAN and NR.	<i>supportedGapPattern</i>	<i>MeasAndMobParametersCommon</i>	No	No	Per UE capability This capability is signalled as a part of <i>supportedGapPattern</i> in TS38.306.	Optional with capability signalling	

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3-4	SU-MIMO Interference Mitigation advanced receiver	1) R-ML (reduced complexity ML) receivers with enhanced inter-stream interference suppression for SU-MIMO transmissions with rank 2 with 2 RX antennas. 2) R-ML (reduced complexity ML) receivers with enhanced inter-stream interference suppression for SU-MIMO transmissions with rank 2, 3, and 4 with 4 RX antennas.	n/a	n/a	No	No
					UE supporting the feature is required to meet the Enhanced Receiver Type requirements in TS 38.101-4	Optional without capability signalling

Annex A (informative): Change history

Change history							
Date	Meeting	TDoc	CR	Rev	Cat	Subject/Comment	New version
2019-04	RAN2 #105bis	R2-1904720				Endorsed skeleton TR	0.0.1
2019-05	RAN2 #106	R2-1905904				TR update as the outcome of email discussion [105bis#11] before RAN2 #106	0.0.2
2019-05	RAN2 #106	R2-1908347				TR update reflecting the latest L2/L3 feature list and capturing the handling of the TR after completion of Rel-15.	0.0.3
2019-05	RAN2 #106	R2-1908456				TR 38.822 v0.1.0 as endorsed at RAN2 #106	0.1.0
2019-05	RAN2 #106	R2-1908511				TR update reflecting the latest RAN1/RAN4 feature lists	0.1.1
2019-05	RAN2 #106	R2-1908512				TR 38.822 v0.2.0 as agreed by RAN2 in email discussion [106#15] after RAN2 #106	0.2.0
2019-06	RAN#84	RP-191034				Presentation to TSG-RAN for approval (no change in contents compared to v0.2.0)	1.0.0
2019-06	RAN#84	RP-191445				Presentation to TSG-RAN for approval reflecting updates during RAN #84	1.1.0
2019-06	RAN#84					TR put under change control and updated to Rel-15	15.0.0
2019-07						MCC: changed the document type from TS to TR	15.0.1